THE MODERN BATTLESHIP

Progress in Naval Construction
By WALTER S. LELAND, S. B.

Physical & Applied Sci. Serials

MAY, 1904

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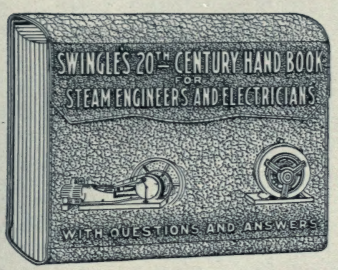

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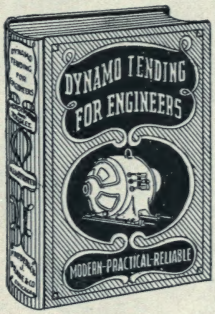

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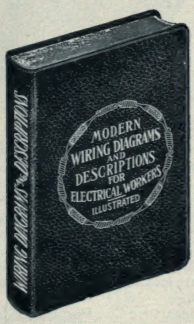

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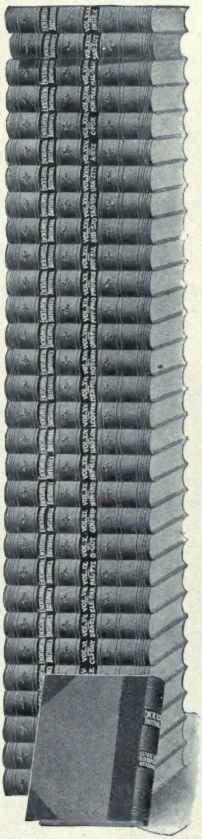

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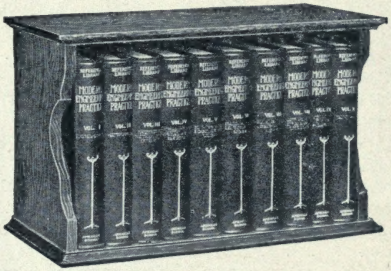

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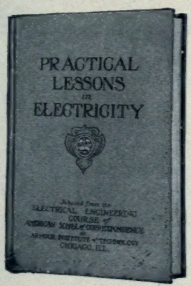

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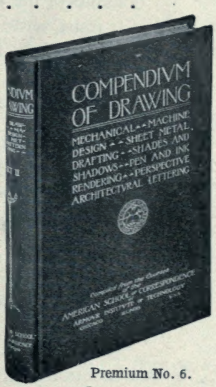

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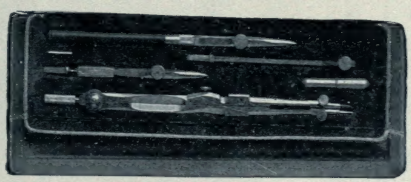

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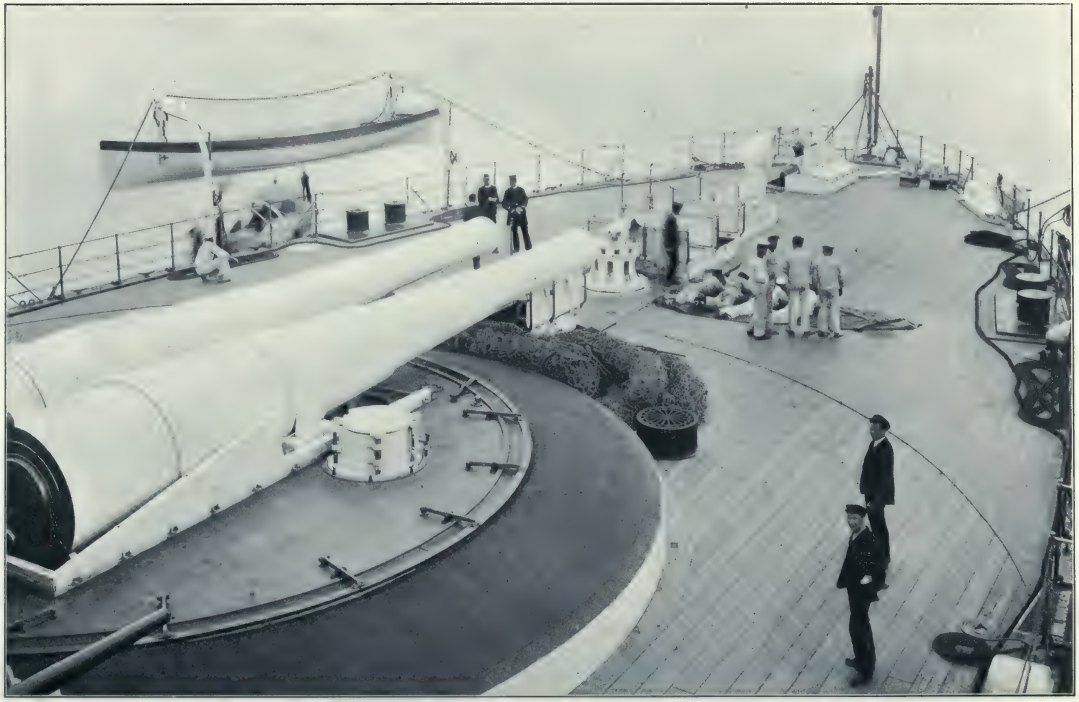

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Volume I *MAY, 1904* *No. 3*

The Development of the Modern Battleship

A Review of Progress in Naval Construction During the Past Forty Years

I.—General Types of Armored Ships

By WALTER S. LELAND, S. B.

Instructor in Naval Architecture, Massachusetts Institute of Technology.

THE present conflict in the Far East has awakened such a widespread interest in naval affairs that a review of the development of the modern battleship affords, at this time, an especially interesting field of study.

The battleship came into existence with the introduction of armor about 1860, and it is the purpose of the present article to trace its growth through a period of nearly forty years. In 1892 the *Royal Sovereign* was launched—an English battleship that represented a strictly modern type. In a succeeding article, a comparison will be made of several of the most recent designs.

Throughout naval history, it has been almost without exception that development in guns and ammunition has preceded the advance in armor, each improved gun, projectile, or explosive necessitating improved methods in the manufacture of armor-plate. The utter worthlessness of wooden vessels was forcibly demonstrated on November 20, 1853, at the battle of Sinope, where the Russian fleet completely destroyed a Turkish fleet of greatly superior numbers, through the disastrous effect of shell fire. The lesson taught was at once put to a practical test by the French Emperor, Napoleon III., who, the following year, had five floating batteries built for service in the Crimean War. The protection to these vessels consisted of 4½ inches of wrought-iron plate set on 17 inches of wood backing.

In June, 1859, the English contracted for their first armored vessel, the *Warrior*. This was the first sea-going armored vessel, and naturally followed very closely in design the wooden frigates of the day. The *Warrior* was necessarily very imperfect, but in point of size, exceeded any warship then afloat, being 380 feet long, 58 feet beam, and having a displacement of 9,200 tons. Like other ships of the day, she was armed with forty 68-pounders,* the largest guns then made. All the guns were on the main deck, but only half of them were protected by armor.

The armor consisted of 4½-inch plates on 18 inches of wood backing; it extended for 218 feet along the side, and was capable of resisting the heaviest projectiles then known. The armor-belt extended a few feet below the water line, and rested on an armor shelf, in many respects similar to those of the present

* The projectile from these guns weighed 68 pounds.

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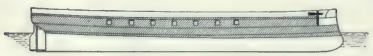
time. The vessel was built of iron throughout, and the unprotected ends were divided into numerous water-tight compartments after the manner of the modern warship. The *Warrior* was a full-rigged ship, but had sufficient engine power to make fourteen knots, a truly creditable performance. One-seventh of

"WARRIOR" (1859).

the total displacement of this vessel was devoted to armor and backing.

Immediately upon the completion of the *Warrior,* the destructive effect of a raking fore-and-aft fire upon the unprotected ends was realized, and three ships of the *Minotaur* class were contracted for. They were completely encircled by an armor-belt 5½ inches thick amidships and diminishing at the ends. In addition to this protection afforded the machinery by the armor-belt amidships, an armored bulkhead was built across the ship at each end of the machinery space. In these vessels the old clipper bow was discarded, and the forerunner of the modern ram adopted.

A few years later, Sir Edward Reed became Chief Constructor in the Royal Navy, and his policy of placing a few heavy guns in a well-armored central *citadel* was adopted. This was the inevitable outcome of the rapid improvement in heavy guns, for it would have been impossible at that time to carry the increased weight of armor around the entire vessel. A narrow belt was still retained around the water line; and bow fire was made a feature of these ships by mounting a single gun at the extreme

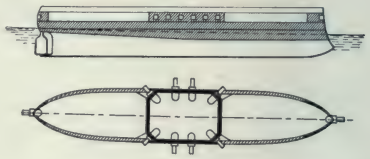


"MINOTAUR" (1861).

bow, behind armor protection of its own. The accompanying diagram of the *Hercules* illustrates this class of vessels.

In America the Civil War was then in progress, and the *Monitor* had fought its memorable battle in Hampton Roads. This justly famous vessel, although the first American ironclad, in no manner represented the development which had taken place across the water. Her armor was of the crudest sort, that on the turret being built up of ten layers of one-inch plate. Her battery consisted of two eleven-inch smooth-bore, muzzle-loading cast-iron guns, which would have made a poor showing indeed if engaged against the rifled cannon being introduced into England at that time. In spite of all her crudeness, however, the *Monitor* was a most important factor in the line of naval progress, for she demonstrated to the world that the revolving turret was a most decided success.

The turret system had been advocated in England for some years by prominent naval men; but it was not until the visit of the U.S.S. *Miantonomah* to British waters in 1866 that the advantages afforded by turrets were fully realized. Three years later, contracts were let for the *Devastation* and the *Thunderer,* embodying this turret system.



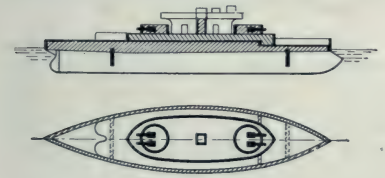
"HERCULES."

The armament of these vessels comprised four 12-inch guns, each weighing 35 tons. These guns were mounted in two turrets, with the axes of the guns fourteen feet above the water level. The hull proper had about three feet of freeboard, with a complete armor-belt 12 to 10 inches thick, set on 18 inches of wood backing. For two-thirds of the length, there was a light superstructure about 8 feet high, affording ample accommodations for the crew. The main deck was protected with 2½-inch armor; and rising above this was an armored *breastwork* enclosing the machinery hatches and protecting the bases of the turrets. Masts and rigging were abandoned; and twin screws, driven by independent engines, gave the vessel a speed of 14 knots. The vessel was 285 feet long, 62 feet beam, 26 2-3 feet draft, and displaced 9,400 tons. The weight of armor on these vessels was nearly one-third of their displacement, the heaviest then known, and they marked the maximum development of both guns and armor at that day.

H. B. M. S. *THUNDERER.*

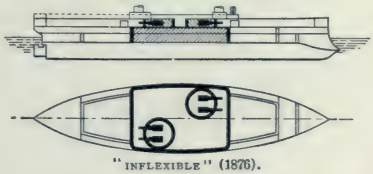
Second-class twin-screw iron-turret ship. Launched in 1877. Displacement, 9,330 tons. Indicated horse-power, 7,000. Length 285 ft.; beam, 62 ft. 3 in.; draft, 27 ft. Armor — Side, 12 in.–10 in.; breastwork, 12 in.–10 in.; turret, 14 in. and 12 in.; backing, 18 in. to 16 in.; deck plating, 3 in.–2 in. Armament — 4 10-in. 29-ton, 6 6-pounder r. f.; 8 3-pounder r. f., 4 machine, and 2 light guns, and 2 torpedo tubes. Speed, 14 knots. Coal capacity, 1,600 tons. Can steam 3,040 knots at 10 knots per hour.

The progress in artillery invention now became so rapid that guns twice as powerful as those on the *Devastation* were turned out. Improvements in armor



"DEVASTATION."

were not so rapid, and, by doubling its thickness, about the same protection as before was obtained. This naturally led to the greatest possible concentration of armor, and in 1876 the British ship *Inflexible* was launched. This ship was 320 feet long, 75 feet beam, 24½ feet draft, and displaced 11,400 tons, being the largest man-of-war then afloat. The only armored portions in the entire vessel were a central *citadel* 110 feet long, and two turrets rising above it. The armor extended for 6½ feet below the water line to the full height of the superstructure (10 feet) above. At the water line the thickness was 24 inches; at the lower edge, 16 inches; and at the top 20 inches. The armor and backing together formed a solid wall 41 inches thick throughout. The most peculiar feature of this ship was such an arrangement of turrets that both pairs of guns could fire ahead or astern or on either side. The turrets were protected with 8-inch armor made up of 3½ inches hard face, welded to 4½ inches wrought iron, set on wood backing, and, inside of this, another layer of armor and backing. The total weight of armor, including a three-inch protective deck, was 3,155 tons.



"INFLEXIBLE" (1876).

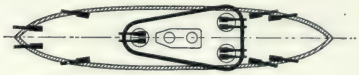
The battery comprised four 80-ton 16-inch muzzle-loading guns. To load them the muzzles were depressed below the

deck level, the deck being slightly raised for that purpose. In addition to the guns, this vessel, for the first time in naval history, carried submerged torpedo tubes.

It is interesting to note that the engines were twin-screw, three-cylinder, compound, with a four-foot stroke. Steam at 60 pounds' pressure was furnished from twelve Scotch boilers. The ship carried 1,200 tons of coal, and developed a speed of 14.75 knots on trial.

"ITALIA."

Many vessels of this type were built both in England and on the Continent; but Italy produced the largest and most unique vessels of the class. These Italian vessels, the *Italia* and *Lepanto*, although not bearing directly on the development of the modern battleship, are worthy of at least a passing notice. They were 400 feet long, 72 feet 9 inches beam, and 28 feet draft, having a displacement of 13,480 tons. They carried four 100-ton, breech-loading guns of 18 inches bore, which were mounted in pairs at the extraordinary height of 32 feet 8 inches above the water line. The guns were on turntables behind a single barbette of 18-inch armor, which effected a very material saving in weight over the ordinary turret type. The only armored portions of this vessel besides the barbettes, were narrow bitts abreast of the boilers, and a protective deck. Four torpedo tubes discharging under water were installed.

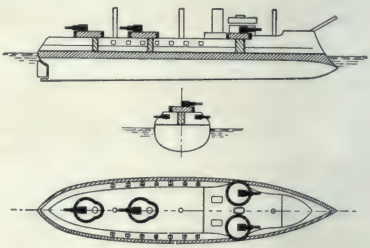


"SINOPE" (1886).

The vessel was driven by twin screws, each shaft being connected to two three-cylinder engines. This was done, partly because of the large size necessary for a single engine, but principally so that at cruising speeds one engine could be uncoupled. The ship could be driven at 15 knots with 15,000 horse-power.

In the ten or twelve years following 1880, France and England took the initiative in naval progress, though each along widely different lines. Russia, too, was acquiring a large fleet, but with a few exceptions her vessels were two or three years behind the times, until the *Sinope*, in 1886, was recognized as the representative of an advanced type. She was the first battleship to be fitted with triple-expansion engines. Vessels of this class have a water-line belt of armor extending throughout the entire length of the ship, and a central barbette enclosing six 50-ton guns arranged in three pairs.

About this time the United States was just beginning to build her "New Navy" and could boast of but two battleships—the ill-fated *Maine* lost at Havana, and the *Texas*. The *Maine* was more properly an armored cruiser, while the *Texas* was of the *Inflexible* type, though smaller and embodying some improvements.



"AMIRAL DUPERRÉ" (1879).

In 1879 the French launched the *Amiral Duperré*, a vessel weak and inefficient in many ways, and yet the forerunner of an important type of ship. The chief characteristics of this vessel were the form of hull and the disposition of armament and armor. Her freeboard was unusually high, placing her main battery 27 feet above the water. Her sides "tumbled home" eight feet, producing the most conspicuous feature of the French warships of to-day. The main battery comprised four 13½-inch breech-loading rifles mounted on separate barbettes, one on each side of the bow, one on the center-line amidships, and one on the aft end of the ship. Thus located, the guns had sufficient height to enable them to fire directly upon an enemy's unprotected deck, and, in theory, concentrate the fire of three guns at nearly every point. An eight-foot belt of 21-inch armor com-

pletely encircled the ship at the water line. The only other armor was that on the barbettes, 12 inches thick, and on the ammunition hoists leading to them. It is not improbable, with such an arrangement as this, that a shell might enter the unprotected hull and explode beneath one of the heavy guns, putting both gun and crew immediately out of action. This of itself should condemn such an arrangement of armor.

The vessel carried a battery of numerous smaller guns on the main deck, being an advance over the preceding one. Only the most important of these types will be described.

The *Collingwood,* launched in 1882, was a barbette ship 325 feet long, of 9,150 tons' displacement. She differed materially from her predecessor, the *Inflexible,* in that the central *citadel* was abandoned, and her four heavy guns, 43-ton breech-loaders, were located forward and aft, in two barbette towers protected by 14-inch composite armor. These guns, as in the *Duperré,* were exposed, but the gun-

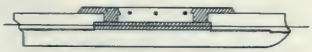
U. S. S. *TEXAS.*

One of the earliest warships of the "New Navy."

entirely unprotected, so that the blast from the big guns interfered with their successful operation. It is reported that the crew had to abandon the smaller guns when one of the main battery was fired in a fore-and-aft direction. The great height of the guns and armor caused a serious loss to the vessel's stability; but in spite of all her faults certain elements of success were there—the complete water-line belt, the commanding elevation of the guns, the high freeboard, and the wide angular range of gun fire.

Great Britain has made the most rapid and consistent naval progress during the last twenty years, and in that time has launched over fifty battleships from thirteen different designs, each succeeding design, with but one or two exceptions,

ners were protected. To load them, the breech was depressed until below the top of the barbettes. Forward and aft of the barbettes, the hull was of moderate freeboard and unarmored. Between the barbettes was a 7½-foot belt of 18-inch

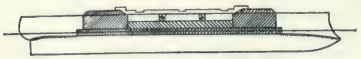


"COLLINGWOOD" (1882, ADMIRAL CLASS).

armor; and at the end of it were athwartship bulkheads of 6-inch armor to protect the ship against a raking fire. Armored ammunition hoists led from the protective deck to the barbettes, and to the upper deck. On the upper deck amidships, were six 6-inch guns mounted

behind one-inch steel plating. This plating was sufficient to protect the men from the fire of the Gatling and Nordenfeldt machine guns, which were then coming into extensive use, but were of no value against heavy fire. The total weight of armor was 2,900 tons.

The design of the *Collingwood* did not provide an end fire to compare with that



"ROYAL SOVEREIGN" (1892).

of the *Inflexible*, but her broadside fire was greatly superior, as her guns could be trained through a wider angle. Her unprotected ends were of considerable length, but still not so great as in the other type. As in the *Amiral Duperré*, there was danger of lodging shells beneath the gun barbettes.

Five similar ships followed the *Collingwood*, each one showing an improvement in minor details. Four of them mounted 67-ton 13½-inch guns instead of the 43-ton guns, while one had two 110-ton, 16-inch guns. These vessels were the fastest battleships afloat at that time.

Two later ships, the *Sanspareil* and *Victoria*, showed an improvement on the *Collingwood* type. They were armed with two 110-ton guns in a single turret, commanding a bow fire of great range. Extending from the turret aft was an armored superstructure containing a battery of twelve 6-inch guns. The only stern fire was from a single unprotected 10-inch gun mounted on the superstructure aft. These vessels were the first in the British Navy to be equipped with triple-expansion engines, and were the last to be fitted with 16-inch guns. The *Victoria*, it will be remembered, was rammed by the *Camperdown* in fleet manœuvers off Tripoli in June, 1893, and went down with 320 men aboard.

In 1892 the *Royal Sovereign* class of seven ships were launched. The length was 380 feet, and the displacement 14,150 tons. In these vessels the 17-inch barbette armor was carried completely down to the protective deck, affording ample protection underneath the turrets. The

H. B. M. S. *CAMPERDOWN.*

First-class twin-screw steel-barbette ship. Launched in 1889. Displacement, 10,600 tons. Indicated horse-power, 11,500. Length, 330 ft.; beam, 68 ft. 6 in.; draft, 27 ft. 3 in. Armor—Side, 18 in. comp.; bulkhead, 16 in. comp.; turret, 12-in.-14 in.; backing, 10 in.-15 in.; deck plating, 3 in-2½-in. Armament—4 67-ton, 6 6-in., 12 6-pounder r. f.; 10 3-pounder r. f., 7 machine, and 2 light guns, and 4 torpedo carriages. Speed, 16.9 knots. Coal capacity, 1,200 tons. Can steam 7,100 knots at 10 knots per hour. It was this vessel which rammed and sank the flagship *Victoria* in 1893, with great loss of life, including that of Vice-Admiral Sir George Tryon, commanding the Mediterranean fleet.

RUSSIAN BATTLESHIP *RETVIZAN.*

Displacement, 12,700 Tons. Speed, 18.6 Knots. Cost, $6,500,000. Disabled by Japanese Torpedo During the First Attack on Port Arthur.

water-line armor-belt extended for about two-thirds the water-line length amidships; it was 8½ feet wide and 18 inches thick. Above this was a lighter belt of 5-inch armor, 6½ feet wide, extending between the barbettes. Ten feet of coal behind the 5-inch armor afforded additional protection. Four 6-inch guns with 6-inch armor protection were mounted on the main deck just above the armor-belt; and six more were mounted on the upper deck, protected only by shields. The rapid-fire armament was large, comprising no less than 28 guns, from 6-pounders to Maxim machine guns. The vessel carried about 4,000 tons of armor protection, had bunker capacity for 1,400 tons of coal, and could steam 18 knots under forced draft. At the date of launch these vessels were remarkable for all-round efficiency, yet they possessed one notable defect. Before loading their heavy guns, it was necessary to swing them back to a fore-and-aft line, which consumed much valuable time.

Up to this time the development of warship design had been very irregular and uncertain. During the last ten years, however, more warships have been built than in the preceding thirty, and the development has been slow and steady. The salient features of the modern battleship were developed prior to 1892, and since that time the improvement has been rather one of detail than of type, the aim being to produce the maximum offensive and defensive power with as little sacrifice of speed and coal capacity as possible.

Interior Illumination

The Conditions of the Problem, and How These Are Best Met in Private Dwellings, Stores, and Large Halls or Public Buildings

By VAN RENSSELAER LANSINGH, S. B.
Illuminating Engineer.

THE importance of economical as well as good illumination is rapidly becoming appreciated by the public as well as by the engineer. At the start it is well to distinguish between the terms "Illumination" and "Light." Light is a *cause*, while illumination is its *effect*. Illumination is the product of two factors—first, the amount of light reflected from the object; and second, the amount of light so reflected which impinges upon the retina of the eye, this, of course, depending on the size of the opening of the diaphragm. This latter factor we shall take up later in considering the question of diffusion. The first factor, however, from its very definition, shows that in order to obtain the best effects, light must be thrown on the object which it is desired to illuminate. It is probably safe to say, at the very least figure, that fully 25 per cent of artificial light is used in illuminating objects which it is not desired to light.

Generally speaking, there are four factors which must be taken into account for good illumination. These four factors can be roughly classified as (1) Steadiness; (2) Diffusion; (3) Quality; (4) Distribution.

Steadiness.

The question of steadiness no longer plays the important part that it once did, in the days of the old flickering gas flame. The changes in the intensity of such a light, and the vain efforts of the iris of the eye to follow these changes, produced in time painful and fatiguing effects on the eyes, which sooner or later drove a person to the use of glasses. To-day, with the incandescent lamp and the Welsbach light, under which most work is done, the light, generally speaking, is very steady, although an enclosed arc on an alternating current of 25 cycles will cause fatiguing of the eye in time.

Another example of unsteady illumination is that produced by a reflector, lined, we shall say, with a white surface, hanging from a cord. Such outfits are generally in more or less constant motion; and, as they produce bright streaks on the paper, which are inherent in the incandescent lamp and intensified by the reflector, the eye is quickly wearied by working under the same. Such cases are very common in drafting rooms, and should be strictly avoided wherever possible.

Diffusion.

One of the most striking changes that has occurred in illumination in the past 50 years has been the very remarkable increase in the intensity of illuminants. This is well brought out by the following table:

Candle	3 to 4
Oil lamp	3 to 8
Mantle burner	20 to 25
Acetylene	75 to 120
Enclosed arc (depending on globe used)	100 to 200
Incandescent lamp (depending on efficiency)	100 to 300
Nernst lamp (bare)	800 to 1,000
Open arc	10,000 to 100,000
Sun on the horizon	2,000
Sun in the zenith	190,000

It is perhaps mainly due to this increase in intensity, as well as to people becoming accustomed to a very much stronger illumination than the eye had been trained to in previous times, that there has been such marked increase in business for the oculist. In order to counteract this extreme intensity, the first and foremost canon of good lighting is to decrease the same, either by entirely hiding the source of light and obtaining only indirect illumination, or, if this is impossible, by diffusing the illumination by some sort of shade.

A very good example of concealed lighting is given in Fig. 1, showing the method employed in lighting a well-known picture, "The Fortune Teller," by Moriana, in the house of Mr. Lorenzo B. Roland, Chicago.

FIG. 1. A PROPERLY LIGHTED PAINTING.

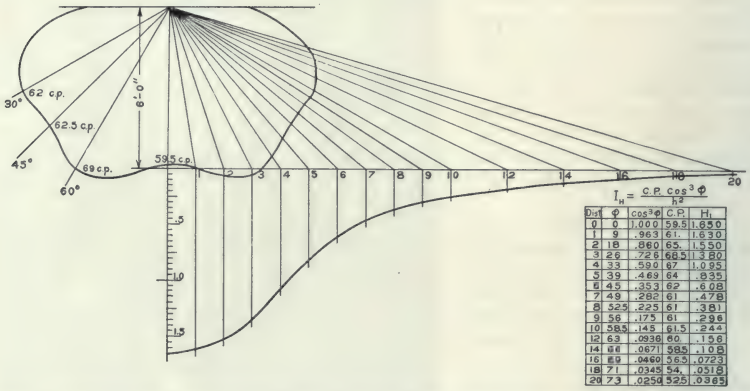
From a photograph taken in the residence of Mr. L. B. Roland, Chicago, Ill.

It should be noted, however, that intensity is not the only factor that produces the harmful effect already mentioned. To this should be added the *quantity* of light, that is to say, the intensity multiplied by the area of the illuminant. Thus, in the case of the mantle burner, in which the intensity is not more than one-fifth that of the incandescent lamp filament, the effect upon the eye is much more harmful than with the latter, as the surface of the mantle is so large in comparison with the surface of the lamp filament. We thus see that, generally speaking, the intensity and quantity of light in modern illuminants must be so cut down as to allow the eye to work with a wide aperture. In the case of the bare lamp this is impossible, especially where such lights are in the line of vision, as the eye tries to accommodate itself to the most intense source of illumination, and is unable to judge properly of other objects less brilliantly lighted. This accounts for the fact that we are unable to see objects clearly when there is a brilliant source of light between the object in question and the eye.

To give a practical illustration of this, and at the same time show how little the fact is appreciated in a great many of our large cities (although it is noticeable that there have lately been great changes for the better), one has only to note the glaring examples on any of our streets at night. Take, for instance, a store with a row of incandescent lights running up and down the windows as well as across. These lights may attract attention from a considerable distance; but at the best, as far as the eye can judge, they but poorly illuminate the goods in the window. There may be plenty of light thrown on the goods, but the eye adjusts itself to the brilliant lights on the frames of the window, and is therefore unable to judge properly of the goods in question. It should be remembered here that all illumination is relative, and that we judge by comparison, the eye itself being satisfied with widely varying illuminations. Thus the illumination on a bright, sunny day is many times as brilliant as even a well-lighted room at night, but the eye is as well satisfied with one as

with the other, for the iris can contract or expand to regulate the amount of light falling on the retina.

We may see along side of such a store, another in which the lights are entirely hidden, but in which, by the use of proper reflectors, the goods are brilliantly



$$I_H = \frac{C.P.\ \cos^3\Phi}{h^2}$$

Dist	Φ	$\cos^3\Phi$	C.P.	H_h
0	0	1.000	59.5	1.650
1	9	.963	61.	1.630
2	18	.860	65.	1.550
3	26	.726	68.5	1.380
4	33	.590	67	1.095
5	39	.469	64	.835
6	45	.353	62	.608
7	49	.262	61	.478
8	52.5	.225	61	.391
9	56	.175	61	.296
10	58.5	.145	61.5	.244
12	63	.0936	60	.156
14	66	.0671	58.5	.108
16	69	.0460	56.5	.0723
18	71	.0345	54.	.0518
20	73	.0250	52.5	.0365

FIG. 2. PHOTOMETRIC AND DISTRIBUTION CURVE OF 12-INCH HOLOPHANE HEMISPHERE, NO. 1202, MOUNTED IN HOLDER. 3-16 C. P. NOMINAL; 49 C. P. ACTUAL.

illuminated with perhaps only one-half the candle-power used in the other case, or even less. The actual illumination thrown upon the goods may be considerably less in the latter store than in the other; but the eye, not being blinded by the lights themselves, is able to work with a larger aperture, and consequently the illumination on the retina of the eye is greater than in the former case.

Incandescent lamps, however, are not the only offenders in this respect. The mantle burner — which is generally equipped with a small white porcelain shade with a clear globe or chimney underneath exposing the bare mantle directly to the eye—is often a good example of something which should be avoided, this being especially the case where mantles are used in cluster lamps with a clear globe. A diffusing globe should be used in such instances, even though involving a large loss by absorption, as the eye can then work without strain.

A common mistake is the supposition that the more illumination one has on an object, the better one can see. In fact there can hardly be a greater error. After a given amount of stimulus, the effect of further light thrown on the retina of the eye is to contract the iris, producing a strain of the muscles. Too much light also affects the retina, producing what is known as an "after image;" that is to say, after looking away from the object, it is possible still to see the same, the image persisting longer than usual owing to excessive stimulation of the optic nerve by the light admitted to the retina. In order to counteract this effect, due to the intensity and quality of the light, it is necessary, provided it be impossible to place the source of light out of the direct vision of the eye, to use some sort of diffusing globe or shade which will decrease the intensity of the light—usually in a marked degree—owing to the absorption of the glass. Some examples of different forms of shades for accomplishing this purpose are considered below.

Quality.

The question of quality can be touched on here only slightly. It may be well to note the predominant color in a few of the most important illuminants. These are as follows:

Sun at noon—white.
Sun near sunset—reddish.
Enclosed arc, low voltage—white.
Open arc—bluish white to violet.

Nernst lamp—white.
Acetylene—white.
Incandescent electric—yellowish white.
Mantle burner—white, with a tinge of green.
Open flame gas—orange white.
Kerosene lamp—orange white.
Candle—orange yellow.

As a general thing, those illuminants which have a yellowish or reddish tinge are best for decorative purposes, because those—like the arc lamp—which have a pronounced bluish tinge give a cold, cheerless appearance, although, from the point of view of economy, the latter are often to be preferred.

The question of color comes into special significance when the problem of matching objects arises; and in this case the goods selected should be compared under the same sort of light as that under which they are to be used. Color is also a matter of extreme importance when we take into account the coefficient of reflection, that is to say, the amount of light which is obtained by reflection from the walls, ceiling, and objects in the room. White paper, for example, reflects from 70 to 80 per cent of light, while dark-blue paper reflects only about 3 per cent. These coefficients of reflection play an important part in enabling us to calculate the necessary illumination for a given purpose. If K is the coefficient of reflection, it is easy to show that the illumination, as directly calculated, should be multiplied by the factor $1 \div 1\text{-}K$ to get the effect from the walls. In the case of a large room this factor may fall to unity; while in a small room with very light decorations it may rise to 2 or 3, or even higher.

Distribution.

Under this head we can make two distinctions:—First, the distribution of the rays of light from a given source of illumination; and, Second, the distribution of the sources of light themselves. Considering the second point first, it is very easy, once having obtained the photometric curves of a source of light, to calculate the resultant illumination at any given distance below the source of light.

In Fig. 2 we have an example of such a curve, which shows the variation in illumination at different distances from the source of light. Having once obtained such curves for the different sources of light used—which, of course, should be obtained with the globes that are actually to be employed—it is an easy matter to calculate the resultant illumination in a room.

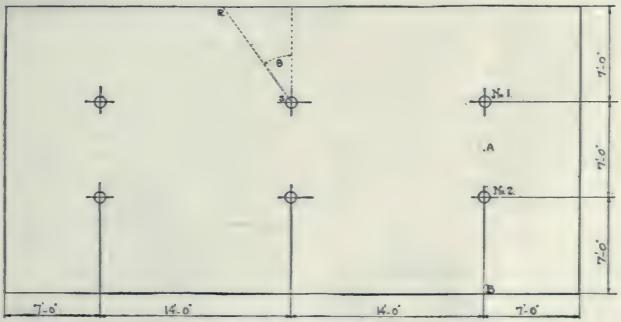


FIG. 3. DIAGRAM ILLUSTRATING POOR SYSTEM OF ILLUMINATION ORDINARILY USED.

Fig. 3 is a good example of how a room should *not* be lighted; it illustrates, however, the method ordinarily employed. If the lights used had the distribution curve shown in Fig. 2, with the height as there given, we should obtain a value at the point A from the lights 1 and 2 of 2.48 candle-feet; while at B the illumination would be 0.602, showing a ratio of nearly 4 to 1 in the illumination. This, however, would be somewhat offset by the reflection from the walls and decorations of the room. It is almost always necessary to make a compromise between the best illumination and the artistic effect desired; and while, if the lights

were placed at a distance of four feet from the walls, point A would receive 1.16 candle-feet, and point B 1.10 candle-feet, it would be best, from an artistic standpoint, to place them about five feet from the side walls, leaving eleven feet space between the two. Illumination, therefore, must be considered not only from an engineering standpoint, but also with a view to artistic and æsthetic results.

Shades.

The question of distribution of the rays of light from the lamp itself, is one which is becoming recognized as of great importance. The desired effect is almost always accomplished by means of different forms of shades. The manufacturers of incandescent lamps are also appreciating the importance of this problem, and there are several forms of lamps on the market which throw more light downward than the ordinary single-loop filament. As lights are almost always used above the level of the eye, and as the objects to be illuminated are almost always as low as the level of the eye, or lower, it is necessary to direct a large portion of the light from a given source into the lower hemisphere, leaving just enough, in the case of interior illumination, to light pleasantly the ceiling and high side walls.

FIG. 4. PAGODA SHADE.

Shades may be distinguished roughly, according to the purposes of their design and the effects they produce, into the following four classes: (1) Decorative; (2) Diffusing; (3) Directing; (4) Diffusing and Directing. The first class are generally used where economy is, at the least, of secondary importance.

The second class, however, is extremely important; and the results are more or less perfectly obtained by using such as opal, opaline, ground-glass, and other forms of shades. The chief objection to diffusing shades is that they absorb a great deal of light, varying all the way from 15 to 60 per cent, and at the same time do not redirect the rays of light as wanted. Thus, a dense opal ball would, while giving perfect diffusion, absorb possibly 50 per cent of the light, and would at the same time cast an equal

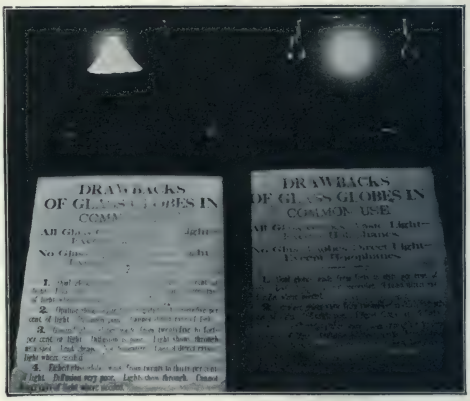


FIG. 5. CONTRASTED EFFECTS OF SHADE AND BARE INCANDESCENT LAMP.

illumination at all angles, giving as much light upward as downward.

The third class—directing shades—is best exemplified by the numerous reflectors on the market. These are more or less efficient, as far as concentrating the light in some given direction is concerned, although if the spherical distribution be taken into account, the efficiency is not extremely high. The chief objection to these shades is that they do not diffuse the light and are apt to cast very marked streaks, besides causing a large amount of regular reflection, especially when used over books, etc., the light for which, coming as it does from below (the eye being accustomed to having the light come from above), very quickly produces fatigue of the retina. An exaggerated case of this is the effect produced by a brilliant white snow, which very soon tires the eye and produces what is known as "snow blindness."

A new form of reflector has recently been introduced on the market, which in a good many respects overcomes the difficulties of the ordinary reflector. This is known under the name of "Pagoda," and is made of perfectly clear glass with a

series of right-angle reflecting prisms on the outside. Fig. 4 shows one style of this, while Fig. 5 shows a comparison of the illumination produced by such a shade and the bare incandescent lamp. A partition was placed between the two lamps, as shown in this photograph, and the resultant illumination was photographed on one plate. It will be noticed in this cut that the shade casts out more or less illumination at all angles as well as underneath, allowing considerable light to go to the side walls and ceiling.

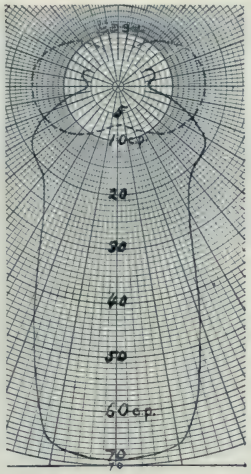


Fig. 6. Photometric Curve of Prism Shade.

Fig. 6 shows a photometric curve of such a shade, and allows one to make a comparison of the bare lamp with and without this shade. It will be noticed that there is a marked increase in illumination at all angles below 22°, and that the end candle-power of the lamp is multiplied nearly seven times. Owing to the prisms, all the reflected light is without the streaks given by most reflectors; but, as the end of the lamp is not covered, there is still to be noticed a slight trace of the same.

The fourth class—diffusing and directing—contain such globes as the McCreary, McFadden, and Holophane. The first two consist essentially of a reflector with a ground-glass bottom, and beautifully accomplish the purpose of throwing a concentrated beam of light without the glare or streaks usually caused by an ordinary reflector, but at a rather high absorption loss, *viz.*, 34 per cent. These are very good for desk lighting, and are much to be preferred to the ordinary green porcelain cone, which throws very marked striations and streaks that are extremely trying to the eye.

The Holophane type of shades is an attempt to obtain both diffusion and direction of the rays of light with minimum absorption. Prof. William L. Smith, who has made extensive tests on these and other globes, reports for electrics a mean loss by absorption of $12\,^{3}/_{10}$ per cent. As these globes play an important part in the exact calculation of illumination, it may be well to examine briefly the principles of the same.

The Holophane shades have a series of annular compound prisms on the external surface, a cross-section of which is shown in Fig. 7. As will be seen, those rays of which it is desired to change the direction by but a small amount, such as A A′, are bent by reflection only. Where, however, it is desired to bend the ray still more, advantage is taken of the principle of total reflection shown in D D′. It will be seen at once that by properly shaping these surfaces, almost any distribution of light can be obtained.

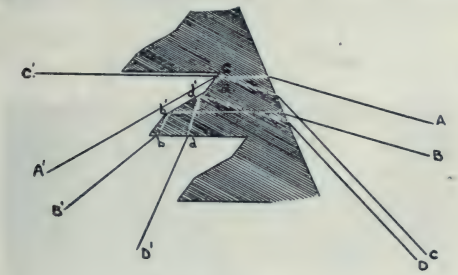


Fig. 7. Cross-Section of External Annular Prisms.

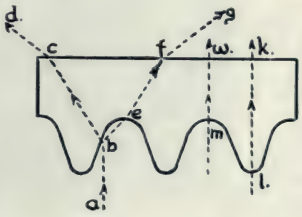


Fig. 8. Cross-Section (enlarged) of Inner Vertical Prisms.

Fig. 9.

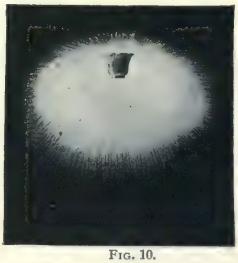


Fig. 10.

Fig. 11.

Various Forms of Diffusing and Directing Shades.

In order to obtain the diffusion, the inner surface of the globe is made with a series of vertical prisms, an enlarged cross-section of which is shown in Fig. 8. These prisms in general follow the

Fig. 12. Holophane Globe.

law of cosines, and, as will be seen, split the ray *a b* into two components, one being simply refracted, while the other is reflected and then refracted. It is evident, however, that such rays as *m n* and *l k*, striking at right angles to the surface of the glass, would not be affected, and the glass would consequently consist of a series of bright streaks. As, however, the exterior prisms are at right angles to the interior prisms, these streaks are broken up, producing a somewhat tessellated appearance, which is observable when closely examined but is in general unnoticed. The perfect diffusion of these globes is only exceeded by a dense opal shade; while their ability to redirect the rays of light, combined with an absorption factor only slightly higher than that of clear glass, renders them in many cases of much value.

Although these globes are made in many shapes and for all forms of illuminants, they can in general be divided into three classes, depending on the way they distribute the light. These are rather strikingly illustrated in Figs. 9, 10, and 11. Fig. 9 shows a type of globe for downward distribution, such as is used on high ceilings, over desks, tables, etc. Fig. 10 shows a type intended for general distribution, the light being thrown almost equally at all angles below the horizontal. Fig. 11 shows a type in which the light is mostly thrown at an angle of from 10 to 20 degrees below the horizontal, and is especially used for lighting large interiors and for street lighting.

The company which manufactures these shades has recently made great

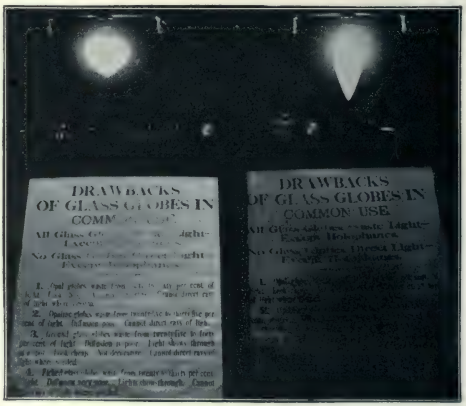


Fig. 13. Contrasted Effects of Holophane Globe and Opal Glass.

improvements, so that now it is possible to obtain globes of almost any shape and size, thus making it possible to throw the light in any given direction.

In Fig. 12 is shown a cut of one style of the Holophane globe; and Fig. 13 illustrates a comparative test between the same globe and an ordinary opal globe. A screen was placed between the two lights, and one photograph was made of the two. This photograph shows very strongly the importance of placing the light where wanted—namely, below the horizontal.

VIEW IN EXPOSITION BUILDING, MILWAUKEE, WISCONSIN.

A good example of Interior Illumination.

Decorative Lighting.

It is impossible in the space of this article to more than touch on the question of decorative lighting. An illustration of a very handsome effect for a large hall, is shown in the Exposition Building in Milwaukee, Wisconsin. In this case the lights on the stringers were equipped with small Holophane globes covered with red shades, so that none of the lights themselves were visible, while the general effect was extremely rich and decorative. In decorative lighting the idea should be, in general, to use a large number of lamps of comparatively low candle-power, rather than a few of high candle-power.

The American Automobile

The History, Functions, and Various Types of the Self-Propelled Vehicle, which has already demonstrated that it is destined to play as important a part as its predecessor, the Bicycle, in the Evolution of Social and Business Life

By E. W. ROBERTS, M. E.
Consulting Engineer.

E. W. ROBERTS.

THE history of the automobile, or mechanically propelled road-car, begins almost simultaneously with that of the steam engine. Nicholas Joseph Cugnot, a French army officer, is supposed to have built what was the first practical self-propelled vehicle, in 1769. Many readers of these pages may be unaware of the historical fact that the road locomotive antedated the railroad by many years. It was the fierce opposition of the populace to this method of locomotion that drove the first vehicles from the highways and caused the early steam engineers to build lines of rails upon which to run their strange carriages. The principal reason for the slow progress made at this time was the erroneous idea that unless there were teeth on the wheels to fit into spaces in the rails the wheels would slip and therefore make little or no progress. Not until 1813 was it demonstrated that the weight on the wheels would be sufficient to prevent them from slipping.

Cugnot built the first self-propelled vehicle in France, but in England the first steam carriage that would run on common roads was built in 1802 by Richard Trevethick, a Cornish tin-miner.

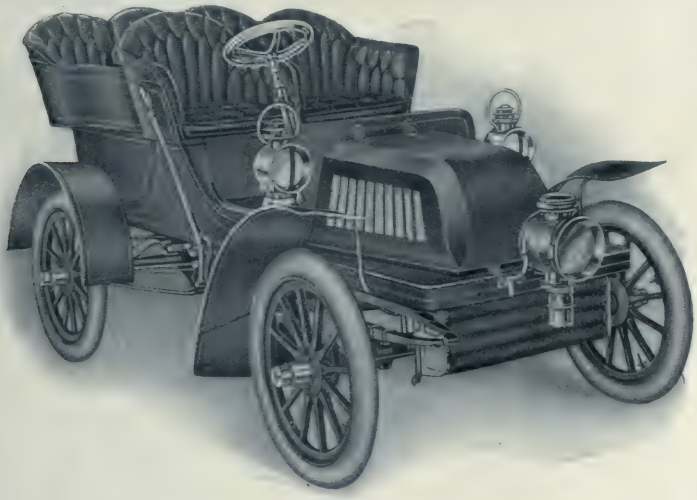
Upon this interesting history it is unnecessary to dwell longer, as this article has to do with the vehicle of to-day, the modern self-propelled carriage now known everywhere as the "automobile."

The history of the modern automobile proper, as evolved in the types of machine to which that name has been applied, covers no lengthy period of time; it is practically all included within the last two decades of the nineteenth century and the few years that have thus far elapsed in the twentieth. As a factor of importance in the industry of the United States, the automobile has taken rank only within the opening years of the present century. For example, four years ago the first attempt at an automobile exhibition was held in conjunction with the Bicycle Show in Madison Square Garden, New York City. In January of this year, the exhibits of the Automobile Show filled Madison Square Garden to the roof, while the bicycle show is no more. Not only was this large building filled with exhibits in the main hall, the basement, and the galleries, but the attendance was enormous. From the sale of space, franchises, and admissions, the promoters are said to have cleared $50,000 above all expenses in the short space of six days and one evening.

Automobiles may be divided, according to the source of power employed, into three classes—namely, *gasoline, electric,* and *steam;* and according to the uses to

MR. E. W. ROBERTS, the writer of this article, is one of the best-known gas-engine experts in this country, and is therefore qualified to speak with authority on the subject of the Automobile. He is a native of Pennsylvania, and a graduate of Cornell University, Ithaca, N. Y. Was chief assistant to Sir Hiram Maxim in his historic attempts to solve the problem of aerial navigation, and was one of the few present at Baldwyn Park, near Bexley, England, on the memorable occasion, July 31, 1894, when Mr. Maxim's flying machine actually raised itself—the first achievement of the kind on record. Mr. Roberts is the author of "The Gas-Engine Handbook," "On Marine Motors and Launches," etc., and has been a frequent contributor to the technical press.

which the machines are put, into *pleasure* and *commercial* vehicles. The pleasure vehicles are of many kinds; but, with a few exceptions, they may be said to comprise two general classes—one, the "runabout," a light car with a single seat; the other, the "touring car," provided with two or three seats. The commercial vehicles are of many kinds, and include cabs, omnibuses, drays, and delivery wagons.



A LUXURIOUS GASOLINE TOURING CAR.

In relation to the form of power employed, the gasoline engine predominates, with electricity next, and steam power last. Among pleasure vehicles, the gasoline engine is by far the most important factor. For city use it is in every way as practical as the use of either steam or electrical power, while for making long trips in the country it far surpasses its rivals in convenience.

The reasons that the gasoline engine outclasses the other motive powers for touring are that, as compared with steam, more power can be obtained for the same weight; there is less mechanism to be cared for; and there is a great economy of fuel, which permits a longer tour on the same fuel supply. As contrasted with electricity, either the gasoline or the steam automobile can obtain a new stock of power-giving material at almost every country store, can be replenished in a few minutes, and can be made more powerful for the same weight of machine, while the electric vehicle is dependent upon electric power stations for replenishment and cannot be made ready to continue its journey without a delay of several hours.

In the city the electric vehicle has its main field of operation; and for those who do not care either to study the mechanism of their cars or to employ a chauffeur, it is the vehicle *par excellence*. The manipulation is easy to learn; and so long as the trips are not of great duration, or there is no desire for speed, it is an excellent machine. However, until the advent of the Edison storage battery, which is now upon the market, the greatest drawback to this type was the uncertainty of the battery. The lead cell, while a good servant in the hands of a careful and intelligent user, is very easily ruined by careless handling. While the "Amer-

ican Wizard" has given us a battery that is more expensive than the lead, and one as heavy for its output, the Edison storage-battery cell may be charged and discharged more rapidly, and will stand more abuse, than its predecessor.

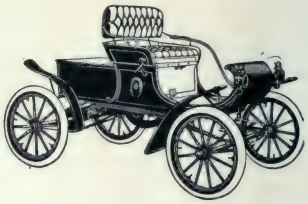
AUTOMOBILE "BUS."

A combination of the commercial and pleasure types, built by the Vehicle Equipment Company.

In the field of commercial as distinguished from pleasure vehicles, electricity is in the ascendancy, with gasoline a close second, while steam is not far behind. In England, the home of the steam lorry, the greater portion of automobile trucking is by steam power.

Since the gasoline vehicle is the type of automobile most frequently seen in America, its description will take precedence over that of the others. In any vehicle the motive power is the most important factor. While it is true that the other parts of the machine require intelligent care in design and construction, yet without a good engine a good automobile is absolutely out of the question. Unfortunately, the gasoline engine is to many a mystery; while to a few people the fact that the power to drive it is obtained from an explosion, makes them believe it something to be feared.

All practical gasoline engines of the present day are of the "reciprocating" type, transferring the pressure derived from the explosion of a mixture of gasoline vapor and air to a piston confined in a cylinder, and thence to a rotating shaft. All gasoline automobile engines are single-acting; that is, the power impulse is given to only one end of the piston. These engines are of two types—the "four-cycle" and the "two-cycle." In the four-cycle engine, four strokes of the piston, or two complete revolutions of the crank shaft, are necessary to complete one series of operations in the cylinder. In the two-cycle engine, but one revolution, or two strokes of the piston, are required



CURVED-DASH RUNABOUT.

for the completion of one series of operations.

The series of operations in a four-cycle engine may be described briefly as follows: As the piston moves forward, it draws by suction into the cylinder a charge of air saturated with gasoline. When the piston returns, the mixture is

trapped in the cylinder, and the return of the piston compresses it to about eighty pounds per square inch. As the piston nears the end of the stroke, an electric spark sets fire to the charge, which explodes, the pressure rising with comparative slowness at first and then with extreme rapidity. The next stroke begins the second revolution of the shaft, and the explosion has raised the pressure to over 300 lbs. per square inch. The piston moves forward and the pressure falls, the gases expanding as in a steam engine. When this stroke is nearly complete, a valve opens and the burned gases escape, being driven completely from the cylinder by the return stroke of the piston.

In the two-cycle engine, the suction stroke and the exhaust stroke are eliminated, each cylinder having an explosion at each revolution of the shaft.

Nearly all automobiles are driven by four-cycle engines chiefly for the reason that the high-speed two-cycle is not very well understood by the average designer, and also because the four-cycle engine has been the type exclusively used by French and other European factories.

As the gas engine is limited in the power of the impulse that is given to the piston, a gasoline automobile is practically always arranged with a set of gears for decreasing the ratio of the speed of the rear wheels to that of the engine.

A MODERN STEAM TOURING CAR.

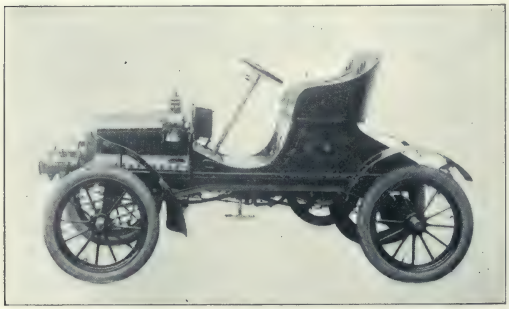
The series—or "cycle," as it is generally called—is now complete, the next stroke being a suction stroke and the beginning of another cycle.

In the two-cycle engine the space about the crank shaft is enclosed, and is used as a pump to draw in the charge and force it into the cylinder. The exhaust gases escape during a short portion of the expansion stroke, and the fresh charge is driven into the cylinder immediately thereafter. The fresh charge is then compressed, ignited, and expanded as in the four-cycle engine.

For instance, the engine is usually connected to the rear wheel in such a way that for ordinary speeds it makes from three to four times as many revolutions per minute as the driving wheels of the machine. For the purpose of hill climbing where the grade is more than about ten per cent, or for traveling over bad roads which are covered with soft sand or deep mud, it is necessary to run the rear wheels very slowly, comparatively, in proportion to the engine speed, thus increasing the thrust at the wheels.

In the light runabouts, for example,

where the engine is of 6 H. P., there is usually one change of speed in the transmission gear with a reversing mechanism. The "low speed," as it is called, will change the ratio to from three to four times the ratio of the "high speed" if directly driven. If the ratio on the high gear is 3:1 from the rear wheels to the engine, the ratio of the low speed will be from 9:1 to 12:1. In other words, if the car is geared to run at 20 miles per hour when the engine gives 800 revolutions per minute, and the low gear is 4:1, the car will run at five miles an hour on the low gear at 800 revolutions of the engine per minute. In many of the runabouts and in practically all of the touring cars using engines of from 12 H. P. up, the transmission gear is fitted with an intermediate gear which usually gives a speed half that of the high gear, and, in case of the example just given, the car would run on the intermediate speed at ten miles per hour. In a very few of the high-powered cars, four speeds ahead are employed.



RUNABOUT, OF TOURING-CAR PATTERN.

The transmission gears are of various types. In light cars there is employed what is known as the "planetary" system, which, briefly described, consists of a central gear of from 20 to 30 teeth on the power shaft. This central pinion is surrounded by three or four smaller pinions of from 16 to 20 teeth. On the outside of these is an internal gear with the teeth inside of a ring. The central pinion is driven directly from the engine shaft, while the pinions surrounding it are on short shafts—or "studs," as they are called—which are fastened to the plate connected to the sprocket or gears that drive the rear wheels. When the internal gear is held so that it cannot rotate, the plate carrying the studs for the small pinions revolves at a slower rate than the central pinion and results in reducing the speed from the engine to the rear wheels. The usual way of operating this form of gear is to use a band clutch on the outside of the internal gear, which, when closed, keeps the internal gear from rotating.

In larger cars two forms of gear are employed. That most generally in use is known as the "sliding" or "clash" gear, in which the pinions are arranged like the back gears of a lathe. When it is desired to change speeds, one set of gears is slid endwise on its shaft, throwing the gears in and out of mesh. With this system of gears, it is necessary to use a clutch between the engine and the transmission gear, and this clutch is thrown out so that no power is applied to the transmission gear when the gears are sliding in and out of mesh to change the speed ratios. This is necessary in order to prevent stripping the gear teeth. This system, which has its origin in France, is seemingly harsh; but it has proved very good in practice for the reason that but one clutch is employed instead of a multiplication of clutches, as in other systems.

A third system, used on some of the large American cars, is that known as the "individual clutch" system, in which the gears are arranged somewhat as in the case of the sliding gear, but so that they remain always in mesh, and the different speeds are thrown in by a system of individual clutches. The power is transmitted to the rear wheels either by gears or by chains.

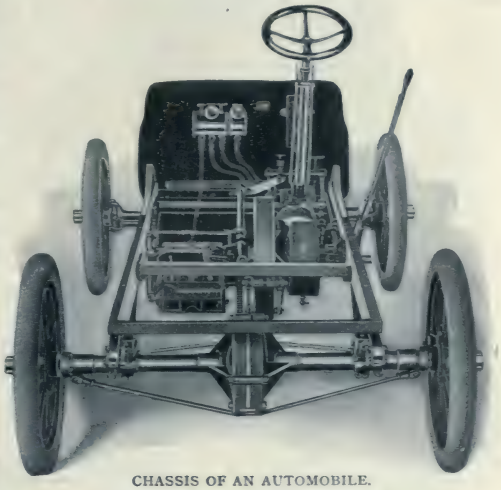
A fourth system employs friction plates or discs. On a light car driven by a chain, the rear sprocket is in the center of the axle, which is made in two parts and which runs with either roller or ball bearings contained in tubes. The sprocket is bolted to a differential or equalizing

gear. The latter is a combination of gears which permits either one of the rear wheels to turn faster than the other when the car is going around a corner. If it were not for the differential gear, the wheels would slip and would wear the tires badly in turning. In some of the large cars, the differential is placed in the transmission case, and two chains are used, with the rear sprockets bolted directly to the hubs of the wheels. In the chainless cars the power is transmitted through a shaft containing universal couplings and bevel gears on the differential; while with some of the very light cars the transmission is hung directly on the rear axle, and, instead of bevel gears, two ordinary spur gears are used.

Practically all of the modern cars are so arranged that the part containing the seats is entirely separated from the framework and the mechanism. That part of an automobile which remains after the body is removed is called the "chassis," and represents all the machinery of the car. The chassis is assembled on the frame, which is usually made of steel, either riveted together from common light angular or channel steel known ordinarily as "structural shapes," or from shapes made up expressly for the purpose by means of large hydraulic presses. The greater number of large cars use pressed steel frames, and a few of the more moderate-priced cars are built with wooden frames usually armored or plated with sheet steel or sheet iron. These frames are supported by laminated steel springs of the usual type employed in carriages, but much stronger and stiffer. A large number of the lighter cars use what is known as the "full elliptic," which is the style employed on buggies. In touring cars, "half-elliptic" springs are used, which are practically the lower half of the full-elliptic springs. Under heavy load these equal the full-elliptic in resiliency, while they give greater lateral stability.

The front axles are in nearly all cases tubular, and have some sort of forked attachment, on the outer end of which are hinged the steering knuckles, the latter consisting of short axles to carry the front wheels, and arms to which are attached the steering mechanism.

The rear axles are solid, except in the case of racing cars and of some of the high-powered touring cars. The rear wheels for the central drive are keyed directly to the axle, which runs inside of a steel tubing. In the case of the double-chain drive, the rear axle is continuous, and the wheels are on the ends of the axle as in a wagon, with the exception, of course, that either roller or ball bearings are used. The wheels themselves are now nearly always made of the artillery pattern, either with wooden spokes and rims or built of tubular steel, the wire wheel having practically gone out of use. The wire wheel was well adapted to the light and lightly-loaded bicycle, but lacks the strength required for the heavier automobile.



CHASSIS OF AN AUTOMOBILE.

For pleasure vehicles, the tires, with rare exceptions, are pneumatic, single or double-tube. Single-tube tires are used only on light and cheap cars.

All cars are fitted with one or more brakes, and usually in duplicate, one method being to employ a brake on the

differential gear, which of course will act, through the differential, on both wheels. This brake is usually supplemented by what is known as an "emergency" brake, operating upon drums bolted directly to the rear wheels.

Steering is accomplished by means of either a lever or a wheel, it being the general practice to employ the lever for light cars only, while the wheel is employed both for many of the lighter cars and for practically all of the heavier type. With a lever steer the connection is usually direct, by means of rods from the bottom of the steering-post; while with the wheel, the movement of the steering-post is transmitted either by a screw and worm

RUNABOUT PREPARED FOR STORMY WEATHER.

With leather or rubber top and rubber apron.

sector or by a screw and nut. Various other combinations are employed, but the two mentioned are those most generally used. The wheel steer is usually made so that the front wheels cannot move without turning the steering wheel; while with the lever steer, unless the steering check is used, the movement of the front wheels may be transmitted to the levers.

Because of the great quantity of heat generated by the combustion of gasoline, some means of cooling the cylinder walls must be employed; otherwise the working parts of the engine would become so hot as to interfere with their operation. The cooling is accomplished either by means of a water jacket, or by means of radiating fins which are attached directly to the cylinder walls. When the engine is water-jacketed, the water is pumped through the engine and thence to a "cooling coil" or "radiator," as it is variously called. This radiator is a coil of either brass or copper tubing on which are soldered a number of small discs. Another form of radiator consists of a number of thin sheets set closely together, with small interstices through which the water is compelled to pass, and of which the outside appearance is similar to that of a honeycomb. In this form of radiator, the water is broken up into a number of very thin layers, and cools rapidly. Generally a fan is located back of the radiator, which serves to draw the air through at a rapid rate.

The upper part of an automobile consists of the "body" and of the "hood" which covers the engine when the engine is placed in the front of the car. The greater number of automobile bodies are made of wood and are of similar construction to those used in carriages, only they are in general more strongly built than the latter, and the workmanship is generally of the very best. The framework of the body is usually of ash, and the panels are of poplar, a wood which will not warp when it is wet. The seats are upholstered in most cases with hand-buffed leather, usually in what is known as the "biscuit" pattern. The modern automobile seat is modeled more after the shape of an easy chair than after the common form of carriage seat. The better class of automobiles have the front seat divided so that it has the appearance of the upper parts of two arm chairs placed side by side. This is designed for the convenience of the operator, so that the passenger occupying the other front seat will not be thrown against him and interfere with his operation of the steering wheel or the levers.

With seats for four, the fashion for the rear seat is usually the *tonneau* (a word derived from the French word for "cask," on account of the peculiar round form). The main features in the tonneau are that the occupants sit corner-

wise, facing at an angle across the vehicle, and the entrance is generally from a small swinging door at the back. In spite of its great inconvenience, this door has hitherto been the fashion; but the rear entrance is likely to be abandoned for an entrance at the side or by lifting up the front seats, a considerable number of automobiles upon the market this year being constructed in this way. The tonneau is usually made so that by taking out a few bolts or by turning several levers it may be removed entirely, and thus the machine becomes a single-seated vehicle for carrying two persons. The rear of the body without the tonneau, then contains a luggage space with a lid or a platform for carrying trunks, hampers, or other forms of luggage for making tours. This larger form of machine with tonneau is usually known as a "touring car" and is designed for making tours from one town to another over country roads.

The great inconvenience heretofore experienced by automobile tourists in the ordinary type of touring car, when the weather was inclement, has brought about the introduction of the canopy top, with side curtains, and usually supplied with a plate-glass front for the protection of the operator, or, as he is generally known, the "chauffeur." A great number of the touring cars for 1904 are thus equipped. Then there are automobiles with special forms of body in which the rear is enclosed in glass, which are of the type known according to the shape as either the *coupé* or the *limousine*. A few automobiles are built in the form of a brake, with three or more seats, while some have a tally-ho body. There are also, of course a large class of single-seated runabouts not ordinarily fitted with detachable tonneaus; and a considerable number of machines are fitted with *dos-à-dos* seats.

The front of the vehicle in the majority of automobiles is fitted with a hood, or an imitation of a hood. There are a few machines of the runabout type with no pretense of anything of this kind; but since the French introduced the type of machine with the engine in front, the style has become so popular that even when a maker places his engine under the seat, he must have a hood in front in order to make the machine look like the other makes. In a vehicle in which the engine is placed forward, the hood covers the engine and some of the accessory parts, such as the vaporizer and igniting mechanism. If the engine is under the seat, the hood is used to contain the water and the gasoline tanks. With the cellular or honeycomb type of cooling coil, the coil itself becomes the front part of the hood. While quite a large number of the coil-tube radiators are placed in the same position, with the radiator hung below the frame, the hood is quite often made sloping toward the front in more or less graceful curves. Of course, in the fully air-cooled type of engine, there is neither radiator nor water-tank. With one or two exceptions the air-cooled engine is placed in front under the hood, and a grating occupies the position usually occupied by the honeycomb radiator.

AUTOMOBILE COUPE.
A permanent closed carriage.

In the electric vehicles the principle employed is the use of a storage battery, which is charged at a generating station, and from which current is drawn to drive one or more motors connected with the

rear wheels. The battery consists either of one of the various types of lead cell, or of the new Edison cells in which nickel and zinc are employed as electrodes. The current passes from the cells to a controller somewhat similar to that

A POWERFUL MOTOR CYCLE.
A link between the bicycle and the automobile.

used in electric street-cars, and thence to the motors.

It is in the system of control, the location of the motors, and the method of transmitting power to the rear axles, that there is found the widest variation in electric vehicles. In some machines the motors are hung from the framework of the vehicle, and the power is transmitted by chains. In others the motor is hung from the rear axle, and the power is transmitted by what is known as the herring-bone gear, the latter being the form of drive gear employed when a single motor is used. In quite a large number of vehicles, two motors are employed in order to do away with the differential gear; and each rear wheel will then have an independent motor. In at least two types of automobiles that have been brought out, the motor is placed within the wheel itself, sometimes four motors being used, the driving being from all the wheels. This form is especially adapted to the heavier types of vehicles. In some machines the system of control is in the combination of divided battery and resistance, while in others no resistance is employed, but the divided-battery system is employed in connection with a divided field-coil on the motor.

Bodies for electric pleasure automobiles are quite frequently of practically the same form as those used on horse-drawn vehicles, though a few of the later types are built in imitation of the popular gasoline touring car.

The steam automobile derives its power from a miniature boiler and engine, in which the heat for raising steam is supplied by either gasoline or kerosene. The fuel is supplied to the burner under pressure, the fuel-tank being fitted with an air-pump, while a pressure of about 40 lbs. per square inch is employed to force the liquid to the burner. The boilers are of various types, a number of them being vertical-tubular boilers similar to those used in small steam launches or steam stationary engines. Another form is what is known as the "flash" boiler, in which the water is made to pass through very narrow spaces, and, the metal being at a high temperature, steam is formed immediately upon the water coming in contact with it. In this form of boiler, the water is fed to the boiler just as fast as the engine takes steam, and the engine is controlled by the water supply. In a great number of steam automobiles a two-cylinder double-acting engine is employed, driving the rear wheels by means of a chain and sprocket. No transmission gear is necessary, as in the gasoline automobile, because a greater thrust is obtained at slow speed by the engine being made to take steam almost the full length of the stroke. In one type of machine that has become very popular, the compound engine is used, driving the rear wheels through a flexible shaft and bevel gears. Quite a large number of the steam machines employ a condenser made more or less like a radiator on a gasoline machine. The condenser is not used to produce a vacuum, but to return the steam in the form of water to the boiler, so that frequent stops for renewing the water supply may be rendered unnecessary. The pump for supplying the water to the boiler, and the height of the flame in the burner, are automatically controlled by special devices. The modern steam automobile is made to operate at a boiler pressure of from 250 to 300 lbs., while even higher pressure has been employed for racing purposes.

The automobile carriage may be found in practically every type of vehicle which is built to be drawn by the horse. The electric cab, hansom, or omnibus is quite a familiar sight in all of our large cities to-day. Delivery wagons driven by all

of the three forms of power are carrying goods from store to customer with much greater dispatch than is possible with a horse-drawn vehicle; and an automobile delivery wagon will usually do the work of two or three of the delivery wagons

AUTOMOBILE DELIVERY WAGON.

A type of commercial vehicle built by the Vehicle Equipment Company.

drawn by the horse. The automobile ambulance is being adopted with excellent results by many of the large hospitals; and the automobile dray is found to be a great convenience and is in some cases supplied with a power hoist, which is particularly convenient for raising safes or other cumbrous articles to the upper stories of buildings.

Not only can the commercial automobile make faster time and do more work in the same period than the horse-drawn vehicle, but it also takes up less room for its capacity, will carry heavier loads, and does not get tired. At times when pavements are slippery and a horse cannot make good progress, and when many horses are laid up through bad bruises or broken bones, the automobile, because of its rubber tire, never falters. The motor vehicle has every advantage over that drawn by the horse in the matter of convenience, speed, and cleanliness. It has entered every field in which the horse is now or has hitherto been employed—drawing fire engines to fires, hauling produce to market, ploughing the fields, etc. And, last, but not least, the automobile involves no expense in the way of feeding when idle.

The Finzi Alternating Current Motor

A Description of a New Type of Machine Which Overcomes Several Serious Practical Difficulties

By ARTHUR L. RICE, M. M. E.
Editor *The Engineer*.

THE advantage of alternating over direct current for the transmission of energy lies in the ease with which, by means of the former, the electromotive force can be raised to high values, so that large amounts of power can be handled on small wires with but little loss of energy. If it were possible to get direct current at high potential, there would be many features—such as the avoidance of induction troubles, the readiness of speed control, etc.—which would in most cases give the continuous form of current the preference.

The difficulty of handling current at high electromotive force on a commutator, which is a necessary part of a direct-current machine, has, however, given alternating current its opportunity. This has been quickly embraced; and the advocates of this form of current have not been slow in claiming everything "within sight" as a legitimate field in which their "pet" was bound to drive the older favorite out of business.

Nevertheless, we have the spectacle of alternating current used for the generation and transmission of power, yet transformed into direct current for the driving of motors. Particularly is this the case where the electric drive is used directly on separate machines so that the speed has to be varied widely, one of the commonest cases being that of the ordinary street car.

On account of the long transmission distances involved, and the great variation required in speed, the hybrid system has seemed almost a necessity in this class of work within city limits. To be sure, some interurban lines have been operated successfully in Europe with polyphase-current systems, but these lines have not involved the frequent slowdowns and stoppages required in street-railway work. Moreover, where a company is operating on its own right of way, there is not the objection to a somewhat cumbersome overhead system that is involved when a road has to build through city streets.

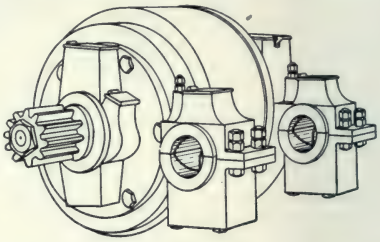


FIG. 1.

Even for power work, the alternating current has been at a disadvantage in the complexity of the line, as three or four wires have to be used on account of the two- or three-phase currents needed to operate the motors. A single-phase synchronous or induction motor will run only after being started and if not overloaded; like many of us, it hates, as it were, to get up and start the day's work; and if asked to pull more load than it deems proper, down it lies, unwilling to start up again until relieved of all load and put upon its feet.

In addition to the complexity of the transmission line, the motor itself is much more complicated when the windings must be laid on so as to take care of

FIG. 2.

two- or three-phase currents. To be sure, the polyphase motor can be built so as to utilize its weight to better advantage than the single-phase machine, so that a motor of given weight will have greater horse-power capacity. The greater complexity, however, will make the cost per horse-power about the same in the two styles.

Verily, then, a good single-phase motor which will start itself, whose speed can be varied, and which is free from complications, is an apparatus much to be desired.

The series form of motor, having the same current flowing through both field and armature, has been known for many years; but the difficulties of serious sparking at commutator and poor efficiency have always been encountered. Now, however, several motors are being developed along this line, the most notable being those designed by Mr. Lamme, of the Westinghouse Company, and the latest development, by Doctor Finzi.

In appearance, the Finzi motor (Fig. 1) is much like its direct-current brother

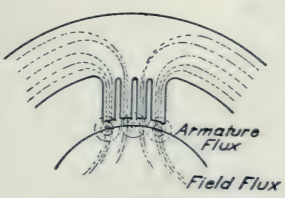


FIG. 3.

which is used for street-car work. The field cores as well as the armature cores are built up of laminations, since otherwise the alternating magnetic flux in them would cause excessive heating. The larger iron loss which has been one evil of former motors of this type, has been reduced by using a low frequency, 15 to 20 cycles per second, as against a frequency of 25 cycles for ordinary power working.

To reduce the sparking caused by the short-circuiting of the coils as the bars to which they are connected pass under a brush, the connections of the coils to the bars (Fig. 2) are made of a high-resistance alloy of german silver, and the low frequency used also assists in this respect.

To prevent distortion of the field by the armature current, and to reduce the inductive effect of the armature magnetism, which makes the current lag behind the voltage, thus lowering the power of the motor, the pole-pieces have slots running lengthwise (Fig. 3), thus breaking the path of the armature flux.

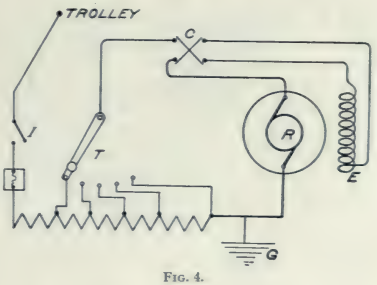


FIG. 4.

The connections of the motor are shown in Fig. 4. Current is taken from the overhead wire of an ordinary trolley system, and is carried to an auto-transformer T. From this, current is led to the motor through a reversing switch C, which reverses the field E, in order to reverse the motor. Current returns from the field through the switch C to the armature R, and then to the transformer. The connection at T is arranged so that the electromotive force applied to the motor can be varied, thus changing the speed. The points correspond to voltages of 80, 100, 120, 140, and 160.

This type of motor was carefully tested at the factory, and showed a relation of current to speed as indicated by the curves shown in Fig. 5.

The relation of power factor to speed is shown in Fig. 6; also the relation of efficiency to speed, the upper set of

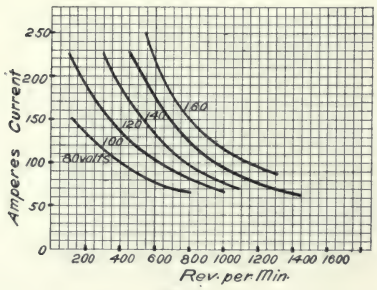


Fig. 5.

curves showing the power factor, and the lower set the efficiency.

In the test on the road, the speeding-up was very smooth, and the commutation sparkless. What few sparks occurred were apparently due only to particles of carbon from the brushes, and were not formed by arcs. The operation was all that could be desired, and, from the reports, was equal to that of the continuous-current motor ordinarily used. As the Finzi motor is of the series type, it will have much the same characteristics as the direct-current motor with the same connections. The speed can easily be regulated, but will not hold constant regardless of load.

This is apparently a good solution of the single-phase motor problem for those purposes for which the series-wound, direct-current motor is available. For the large class of work that requires a constant speed with varying load, the problem is still unsolved; but the solution of one difficulty, which has long been considered insurmountable, gives reason to

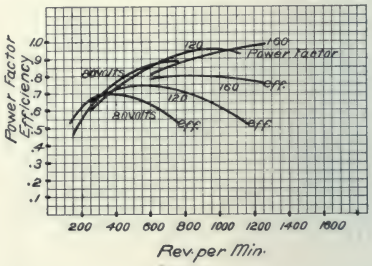


Fig. 6.

believe that before many years have passed, someone, either by working along new lines, or, as in the present case, by careful application of principles already known, will produce a form of single-phase motor that will prove desirable for such work as the driving of machine-tools, elevators, etc.

Electricity at the Louisiana Purchase Exposition

1. The Generation and Distribution of Power

The First of a Series of Articles Describing the Noteworthy Electrical Features of the Universal Exposition at St. Louis

By CALE GOUGH, Department of Electricity

WITHOUT the skill and ingenuity of the engineer, the conception of a World's Fair on a scale as broad and far-reaching as the Louisiana Purchase Exposition would be impossible. His work is the basis of almost all that is wrought out there. Yet the majority of visitors will go away with very little appreciation of what he has done.

There exist within the confines of the Exposition more than a score of features which, looked at from an engineering standpoint, are well worthy of careful consideration. Most of these, however, are so overshadowed by others of larger scope that they will be more or less neglected even by those especially interested in engineering work.

The Generating Plant

Several features, nevertheless, stand out far above their surroundings. Among these is the system for development and distribution of the immense amount of electrical power used in operating the machinery exhibits throughout the Exposition grounds, and in illuminating the thousands of incandescent lamps with which the cornices and columns of the magnificent buildings are so thickly studded.

The aggregate capacity of the score or more of units combining their output is approximately 45,000 horse-power. This is more than eight times the total consumption of electrical energy at the Pan-American Exposition in 1901, remarkable though that was; and almost equals the capacity of the original Niagara Falls power plant.

The greater part of the power plant of the Louisiana Purchase Exposition is made up of units placed primarily as exhibits for the representative manufacturers of the country; but for the generation of 8,000 kilowatts, or about one-fourth the total output, a complete plant —from coal-handling apparatus to switchboard—has been installed.

The contract price for the installation and use of this plant during the period of the Exposition was $1,000,000. This price, of course, does not include the purchase of the machinery. At the close of the Exposition, all this equipment—which will be practically as good as new —reverts to the contractors.

The boilers for the plant occupy the southern portion of the Exposition Boiler House. There are eight batteries, each consisting of two 400-H. P. water-tube boilers, giving a total capacity of 6,400 horse-power. All are equipped with mechanical stokers fed from coal bunkers above, through swinging chutes. The coal bunkers, in turn, are supplied by means of a complete installation of coal-conveying apparatus, which receives the coal from a hopper located between the rails of a siding of the Terminal Railway Company.

Ash pits under each of the boilers receive the ashes as they fall from the grates. An underground tunnel provided with track and ash cars furnish means for readily emptying the pits. The plant

is so well provided with labor-saving devices that from the dumping of the coal into the hoppers to the removal of the ashes, almost no manual labor is employed.

The northern portion of the Boiler House contains various types of boilers placed as exhibits. These present a very interesting appearance because of the many types represented. They include, besides the representative American makes, several of European manufacture.

PALACE OF ELECTRICITY
View from across the Lagoon

These latter have at first glance an appearance which easily distinguishes them from boilers of domestic manufacture. Fuel is delivered to all this group of boilers by means of an overhead conveying system. All of them feed into common steam mains, supplying the exhibit engines in Machinery Hall.

The Boiler House presents a somewhat unusual appearance in that the customary high smokestacks are absent. Mechanical draft equipments account for this, all of the larger boilers being provided with induced-draft systems.

Situated about one hundred feet east of the Boiler House is Machinery Hall, the western extension of which contains all the larger items of the power plant. The heavier generating units occupy the central portion of this extension. Of these, the four generators and the four engines of the complete service plant are situated at the extreme west, or nearest the Boiler House. These four engines, all of the same type—Westinghouse-Corliss vertical cross-compound—are each rated at 2,800 kilowatts. Steam is supplied to them directly from the service plant boilers in the southern portion of the building through two 12-inch steam mains.

Two of the four generators of this installation are of Westinghouse type, rated at 2,200 kilowatts. The remaining two, of 2,000 kilowatts' capacity each, are of General Electric Company manufacture.

The exhibit installations lying to the east of the service plant, consist of several units remarkable for their size and features of design. The most powerful of these is the Curtis steam turbine rated at 8,000 horse-power. The space occupied by this machine leads the casual visitor to consider it much less powerful than its neighbor the Allis-Chalmers 5,000-horse-power engine coupled to a 3,500 kilowatt Bullock generator. This immense engine presents quite a distinctive appearance, its vertical cylinder, massive in construction, standing far above the surrounding machinery.

Grouped around the larger units are a number of installations ranging in size from 500 to 2,000 kilowatts. Lying to the north are those of smaller capacity.

It would naturally be supposed that as these exhibits are to terminate their period of usefulness within seven or eight months after completion, temporary construction would show itself on every hand. On the contrary, however, the appearance of permanency is everywhere present—in the foundation of the engines, in the boiler setting, in the piping, as well as in all the other details of installation. This presents a very strong

PALACE OF ELECTRICITY
View from the East

contrast to the temporary construction of the buildings, the roadways, the bridges, and, in fact, almost everything else lying within the Exposition enclosure.

The Distributing System

For the distribution of the current from the main switchboard at the west end of Machinery Hall to the eighteen substations situated in the various buildings, a complete system of subways has been constructed. These are of a temporary nature, consisting simply of a ditch whose sides as well as top and bottom are boarded over. A few inches of dirt thrown on top hides all evidences of the existence of the subway. Shelves built on both sides of a central passage carry the cables. The largest of these subways measures about seven feet by seven feet.

Telephone, telegraph, and fire-alarm cables, as well as high-potential power lines, are carried in the same subways. The former are placed on the upper shelves. The power cables, carried on the lower shelves, are lead-sheathed, the three cables of the three-wire system being enclosed in one sheath.

Where the distributing system passes under the lagoons and waterways, the wood subways are naturally dispensed with, and at these points a water-tight cement conduit is installed.

In most of the buildings the demand for power is limited to alternating current. The substations in these cases consist simply of transformers and the accompanying switchboards.

A GLIMPSE OF SOME OF THE BUILDINGS

The machinery exhibits in several of the buildings, however, demand direct current for their operation. In the substations of these buildings—including the Palace of Electricity, the Educational Building, and the Building of Mines and Metallurgy—rotary converters or motor generators are installed. In the Palace of Electricity the demands for direct and alternating current at so many voltages and of such frequencies resulted in the installation of the most complete substation on the Exposition grounds.

As the separate items composing the display here are placed as exhibits, the

fire-proof construction used in making the enclosures for the substations of the other buildings was omitted, ample precaution being taken by installing the machinery and transformers on a concrete floor and allowing sufficient space for all needs between these and the other exhibits.

Four complete sets of three-phase transformers are installed. These range in size from 75 kilowatts to 250 kilowatts, the station having a total transformer capacity of 1,575 kilowatts.

The converting apparatus consists of one 200-K. W. 550-volt rotary converter, supplemented by two 100-K. W. 125-volt motor-generator sets, one for each side of the three-wire 110- and 220-volt systems with which the building is supplied. A switchboard with the necessary panels for distribution and connection is placed in the central portion of the 1,400 square feet occupied by the substation.

The high-tension leads are brought directly to the transformers from conduits under the floor. The transformed and converted current is led to the upper portion of the building by means of a post located on the substation space. That part used for lighting the exterior of the building is conducted to distributing boards on the roof. The cables supplying power and light for the exhibits are strung on trusses overhead, from which leads to the separate exhibits are dropped.

The capacity of the transformers in the substation of the Palace of Electricity does not by any means represent the total amount of power available in this building. Several of the exhibits include complete transforming and converting sets.

The great number of different combinations of frequency and voltage demanded by the exhibitors in the Palace of Electricity, and the readiness with which these demands were met, show very pointedly the flexibility of the alternating-current systems. In alternating current six different voltages are supplied, ranging from 104 to 6,600 volts. These, together with the three frequencies (25, 50, and 60 cycles) and the one-, two-, and three-phase systems, give a possibility of fourteen different combinations from the 6,600-volt mains.

Considered from an engineering standpoint, the Exposition power plant and distributing system has been very carefully worked out, and much credit is reflected on those who have had the design and installation in charge.

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Opportunities are often hand-made.

A Chinese laundry ticket is but a mark of irony.

Fools rush in and win—where angels fear to tread.

Worry may have killed a cat, but it wasn't a city cat.

Beware of the silent man; he may be a reformed prize fighter.

Were it not for the fools, the wise guys would get left.

Money is the greatest trouble a man has, when he hasn't any.

Many men work over-time trying to fix up schemes to avoid work.

The best time to read a note or a mortgage is before you sign it.

You can't discourage the prohibition movement by throwing cold water on it.

The unwritten law of society considers every man guilty until he is proved innocent.

Although the giraffe carries his head higher than the porcupine, the latter is more stuck up.

Many a man who thinks he is "it" to-day, will wake up and find himself in the "has been" class to-morrow.

It sometimes happens that the man who has a wife and an automobile, has two unmanageable things on his hands at once.

Our Platform

The Technical World is now far enough advanced in its career to make desirable a more comprehensive statement of its policy, its aims, its scope, and its hopes, than has heretofore been given.

The policy of the editors and of the management is to reach in a helpful, entertaining, and attractive way that great army of people who are either directly or indirectly interested in any field of technical endeavor. To all such—from the boy who likes to "see the wheels go round," to the man of affairs, the "captain of industry"—The Technical World aims to appeal.

Short articles on live topics of interest to all workers—bright, forceful, timely, scholarly, yet unburdened with heavy technicalities that would lower their interest to all but the scientifically expert—will be furnished in abundance. For a broadening influence, a few articles having perhaps a rather remote technical connection, but intended to keep the readers abreast of the times on important current affairs, will be given.

Space will be devoted in each issue to biographical sketches of successful men—men of mark—whose example will furnish inspiration to ambitious readers and encouragement to the as yet unsuccessful.

New books will be reviewed and periodicals gleaned so as to give, as far as possible, the substance of all that is most valuable appearing in the technical and scientific literature of the day.

While the keynote of the magazine may be said to be predominatingly technical, and while it will contain features in a sense reflecting the aims and interests of the great body of correspondence students scattered throughout the world, the element of *general human interest* will be kept prominently in mind. In this way the magazine will appeal to a wider constituency than that merely of the expert or the student; it will have a message for all who are alive to progress and achievement in the various branches of science, engineering, arts, and crafts.

It is the earnest wish of the editors to make the magazine truly helpful. That this may be best accomplished, it is hoped that every subscriber will feel at liberty to help, and will help, the editors—and, in doing so, help himself and other subscribers—by taking an active rather than a passive interest in the magazine. Criticisms, suggestions, items of interest, and requests for information will be gladly received. Let coöperation be the watchword of the subscribers and the editors.

Opportunities in the Engineering Field

MR. DAMON'S PAPER recently read before the Western Society of Engineers, of which the principal portions are quoted elsewhere in this issue, contains a word of cheer for every young man who is ambitious to rise not only in the electrical field—to which the paper is particularly directed—but in the entire technical field, whether relating to Electrical, Mechanical, or Civil Engineering, or any of the allied industries.

We take it that Mr. Damon confined his study of the conditions treated of to the electrical field, because he is a prominent worker in that field; and to Chicago, because that city afforded the best opportunity for him to make his particular studies. The truths set forth in this paper, however, will apply with like force to any industry in the technical field, and to any city or town in this country or in any other country.

The data compiled by Mr. Damon show conclusively that those young men who cannot afford to take a college course to fit them for their life work, need not be discouraged. Twenty of the one hundred most successful electrical men in Chicago have had no college training whatever. The average income of these twenty men is $3,670 per annum, which is $230 higher than the total average income of the entire one hundred men selected.

The thing in this paper, however, which stands out with greatest prominence, is the fact repeatedly referred to, that the ambitious young man must give all possible attention to obtaining a thorough technical education, whether it be in the halls of a great technical university, of a night school, or in his own room by the correspondence method. The keynote of the whole situation, as shown in this paper, is *hard work intelligently applied in the right direction.* The quotation "If I had it to do over again, I would pick out some definite line of work suited to my talents, and work like fury," embodies this idea in a nutshell.

Any man, successful or unsuccessful, old or young, in looking over Mr. Damon's "Specifications for Success" may at first thought feel discouraged on account of his shortcomings. It is safe to say, however, that no one has ever yet attained one hundred per cent efficiency along the lines of Mr. Damon's specifications; and, remembering this, the tendency to discouragement should give place to a well-defined determination to come up to these specifications as closely as possible.

Possibilities of Radio-Activity

THE last sentence in the article on Radium by Professor Millikan, which appeared in the March number of THE TECHNICAL WORLD, contains a thought of special significance to those who feel that radium in particular, and radio-activity in general, will overthrow many of the present well-defined laws of science, and render useless, because inaccurate, much of our scientific knowledge so far acquired. Statements to this effect are often seen in the newspapers, and apparently are believed to a greater or less extent by a large class of people. As an example, read what a certain "Professor" Gage, as reported by a San Francisco paper recently, will accomplish with a new "radium battery:"

"With batteries charged with this new radium preparation," says Mr. Gage, "I will guarantee to startle the scientific world with my experiments. I will guarantee to run a big automobile filled with passengers a distance of 300 miles with one charge. This is only one of the many things which I will guarantee."

From this it would seem as if radium were going to "revolutionize the mechanical world" as well as overthrow all our long-accepted laws and hypotheses of science. Nothing, however, can be further from the truth. Doctor Millikan, in the sentence referred to, says:

"But even though no practical applications of the discoveries of the last eight years should be found, radio-activity will have served what is surely one of the most useful of all ends—namely, that of enlarging our knowledge of the ways of nature."

Instead of overthrowing well-established scientific laws, or rendering our knowledge of physics and chemistry useless, radio-activity will, as it becomes better understood, afford a deeper insight into these laws, and will doubtless show us that the laws are correctly formulated as far as we have gone, but that we have not gone far enough. The well-known law of the conservation of energy, for example is, to all present appearances, not followed by the action of radium. Scientists know, however, that this is not true —that radium in all of its actions, known or still unknown, will be found, when fuller light is thrown upon it, to obey this fundamental law just as accurately as do all other natural phenomena. When more is known of radio-activity, we venture to state that the law of the conservation of energy, as well as all other well-defined physical and chemical laws, will not only stand, but will, so to speak, stand on a new cement foundation.

The Walking Locomotive

THE article by Consul Boyle, on a new type of traction engine, is interesting, not only because a radical departure in any well-established line is always of interest, but because it gives some of the ideas entertained by a noted British authority on the possibilities and probable future of this new machine.

We admit that the "pedrail" is a radical departure, that it is an ingenious attempt to make a machine perform the duties of an elephant as an elephant performs them; but we cannot place ourselves in accordance with Professor Hele-Shaw in predicting for it any far-reaching or revolutionary change in our present traction methods.

To the practical mind the wheel, with its rigid construction, its single bearing, and its well-proven efficiency, is not to be lightly put aside for such a device as the pedrail, with its multitude of feet, "sliding spokes," roller bearings, and "portable rails."

If the present wheel tears up the British roads, does not adapt itself with sufficient flexibility to uneven roads, or to those regions having no roads at all, then the solution, it seems to us, lies in one of two directions: either modify the roads, or modify the wheel without unduly sacrificing its simplicity. In most cases the road is already sufficiently developed to need no such freak of mechanical ingenuity to afford traffic over its surface. There are, however, and probably always will be, many localities where roads of this nature cannot be provided or maintained. There will always be new territory in a stage of greater or less development, in which there is undoubtedly need of a better form of traction engine than any now available. These localities are, however, in a more or less primitive state; and on this account the need for a simple device is all the more urgent. Can this elephantine locomotive, with its multitude of bearings, its sliding spokes, and its portable rails, ever supplant the wheel even in such localities?

Our British Visitors

THE spring meeting of the American Society of Mechanical Engineers will be held in Chicago, beginning May 31, and continuing until June 3. Chicago was selected on account of its proximity to St. Louis, its fine hotel accommodations, and its industrial plants. This meeting is of especial interest as it is a joint session with the Institute of Mechanical Engineers of Great Britain. Among the topics covered by the professional papers to be presented by the visitors are the steam turbine, the gas engine, motor cars, hydraulic and electric cranes, induction fans, and garbage destroyers.

Mr. Carnegie's Gift to Engineers

ANDREW CARNEGIE evidently appreciates the engineer, and realizes how much modern civilization owes to his work. As a token of his appreciation he has made an offer to give to the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers the trusteeship of a building to cost one and a-half million dollars. This building will be erected in New York City, and will become a center of engineering societies and clubs of the United States.

As the various branches of engineering must, in the very nature of things, go hand in hand, and be in large measure interdependent, the "gathering of the clans," through Mr. Carnegie's most liberal offer, will without doubt be productive of great good.

Branchings Into New Fields

WHILE this is an era of industrial combinations, it is also one of industrial specialization. The tendency on the part of corporations to combine does not always work in harmony with that toward specialization. Instead of a manufacturing company confining its efforts to a certain class of manufactured output, allowing other companies to work in other lines, the advantages to be gained by forming combinations often lead companies to step over into fields hitherto left wholly to others.

In this connection the recent enlargement of the scope of operations of the Allis-Chalmers Company is of interest. This company will not only continue to manufacture reciprocating steam engines, but will also become producers of three other kinds of prime movers and steam turbines, hydraulic turbines, and gas engines. It will also enter the electrical field in the manufacture of a full line of electrical power machinery and accessories.

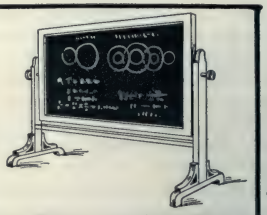
It will therefore be possible for a single company to manufacture the complete equipments for power plants using any type of prime movers. The advantages to operating companies, due to the definite fixing of the responsibility for the entire power-plant equipment, would seem to overcome any criticism that might be made on the ground that the company was losing efficiency by not concentrating in a single field of work.

In addition to this latest movement of the Allis-Chalmers Company, the similar movement on the part of the Westinghouse Companies and the General Electric Company, toward engaging in the manufacture of engines other than those of the until now almost universally used reciprocating steam engine, is also of great significance. It greatly strengthens the position of the steam turbine and gas engine in the race for supremacy over the reciprocating steam engine. It will assure to the gas engine and steam turbine a proper development, by which alone a comparison of the three types of engines can be made strictly on their merits.

An Omission Rectified

THE discussion as to the comparative merits of the Panama and Nicaragua canal routes, by Gen. Henry L. Abbott, which appeared in our April number (p. 143), was originally published in *The Engineering Magazine*. It was through an unintentional oversight on our part that the courtesy of that publication was left unacknowledged, and we are glad of the opportunity to supply the omission.

CHALK TALKS



by CARL S. DOW.

III. THE GAS-ENGINE CYCLE

ALTHOUGH many people think there is something mysterious in the working of the gas engine, it is, in fact, simpler than any steam engine. The fact that the power is derived from the explosion of gas in a cylinder does not increase the difficulty in understanding it.

Let us first consider the most common form of gas engine, the single-cylinder "Otto," or "four-cycle," as it is usually called. This engine has a single cylinder, which is open at one end and is fitted with a long piston that is also the crosshead. Since the gas and air are admitted at one end only, the engine is single-acting; that is, power is applied at but one side of the piston. The clearance space is large because of the volume of gas and air to be exploded. There is no piston rod. The connecting rod is jointed to the piston at one end and to the crank-pin at the other.

In the four-cycle gas engine, the mixture of gas and air explodes in the head-end of the cylinder once in every two revolutions of the fly wheel. Thus there are but one-fourth as many impulses given to the piston as in the ordinary steam engine.

SEQUENCE OF OPERATIONS

First Stroke

Let us suppose the piston to be moving to the right, as shown in the first diagram on the blackboard. The admission valve A is open; and, as the piston moves, air and gas are drawn into the cylinder. The exhaust valve is closed. When the piston reaches the end of the stroke, the cylinder is filled with a mixture of gas and air at practically atmospheric pressure.

Second Stroke

When the piston commences the return stroke it moves to the left as shown in the second diagram. During this stroke both admission and exhaust valves are closed; and, as there is no way for the gas to escape, it is compressed by the advancing piston.

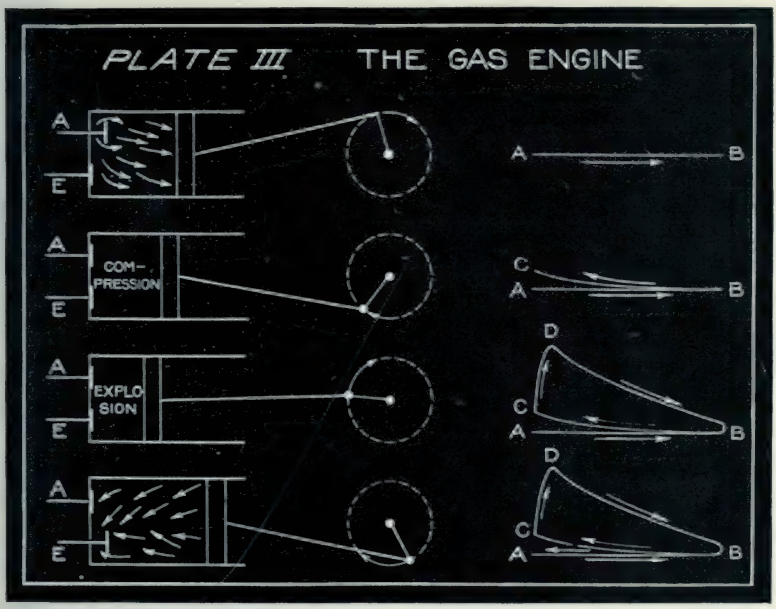
Third Stroke

Just as the piston reaches the end of the second stroke (see third diagram), and the gas is compressed in the clearance space, the mixture is ignited by an electric spark or gas flame. This causes an explosion; the pressure rises suddenly, due to the explosion, and the piston is driven toward the right. The explosion being almost instantaneous, continues but a small fraction of the stroke. The pressure rises rapidly while the piston moves but little. After the explosion the piston moves toward the right, and the products of combustion expand; but, as the pressure continues to be greater than atmospheric pressure, it drives the piston before it.

Fourth Stroke

At the end of the third stroke, the exhaust valve opens; and the piston, moving toward the left, drives the waste gases out of the cylinder.

The cylinder is now ready for a new charge of the mixture, which is admitted as shown in the first diagram.



Diagrams

We may represent graphically the variation in pressure within the cylinder by means of diagrams. Let us represent volumes by horizontal lines, and pressures by vertical distances. Then the line A B (proportional in length to the stroke) represents the volume of the cylinder, and is a straight, horizontal line, since the mixture during admission is at constant atmospheric pressure.

During the second stroke, the mixture is compressed, and the pressure rises, as shown by the curve B C.

The explosion causes a sudden rise in pressure, represented by the line C D, which is nearly vertical. During expansion the pressure gradually decreases as the piston moves to the right, and the curve D B approaches the horizontal line.

At the end of the third stroke the exhaust valve opens, and allows the gas to escape. As this occurs at practically atmospheric pressure, the line representing this stroke is almost coincident with the line of the first stroke. Its direction, however, is opposite to that of the first stroke.

The operation of the gasoline engine is the same. The chief difference between the gas and gasoline engine is that, in the latter, gasoline is vaporized, and the vapor, mixed with air, enters the cylinder.

Great Technical Schools

III.—Rensselaer Polytechnic Institute

By PALMER C. RICKETTS, C. E., Director

THE RENSSELAER POLYTECHNIC INSTITUTE is located at Troy, N. Y. It was founded under the name of the "Rensselaer School" in the year 1824, by the Hon. Stephen Van Rensselaer, of Albany, N. Y. In a letter dated November 25, 1824, to the Rev. Dr. Blatchford, who was the first president of the institution, the founder appointed the first board of trustees and enunciated certain articles for the temporary government of the school. At the same time he made Amos Eaton, of Troy, senior professor. The first meeting of the board of trustees was held December 29, 1824; and the school was opened January 5, 1825. An act of incorporation was passed by the State Legislature March 21, 1826.

The institution was established as a school of practical science. In the letter referred to above, the founder makes the following statement in relation to its character:

"I have established a school in the north end of Troy for the purpose of instructing persons who may choose to apply themselves in the application of science to the common purposes of life. My principal object is to qualify teachers for instructing sons and daughters of farmers and mechanics, by lectures or otherwise, on the application of experimental chemistry, philosophy, and natural history to agriculture, domestic economy, the arts, and manufactures."

The intention of the authorities at that time is further shown by quotations from a circular dated September 14, 1826, which was signed by the president, and to which the names of the trustees and faculty are attached. It was issued to describe an extension of the course, and is entitled: "Preparation Branch Recently Established at Rensselaer School." The curriculum of the "Preparation Branch" is given in detail, and the object of the school is also stated. This is believed to be the first prospectus of a school of science ever issued in the English language. From it we learn that "the Rensselaer School was founded by the Hon. Stephen Van Rensselaer, solely for the purpose of affording an opportunity to the farmer, the mechanic, the clergyman, the lawyer, the physician, the merchant, and, in short, to the man of business or of leisure, of any calling whatever, to become practically scientific. Though the branches which are not taught here are held in high estimation, it is believed that a school attempting everything makes proficient in nothing. The Rensselaer School, therefore, is limited to an experimental course in the natural sciences. The studies of the Preparation Branch are extended no farther than is necessary, as auxiliaries to the experimental course."

"The original method of instruction which has produced such unexpected results, called the Rensselaer method, will be extended to this branch, to-wit, that of exercising the student, on the forenoon of each day, by causing him to give an extemporaneous dissertation or lecture on the subject of his course, from concise written memoranda, and to spend the afternoon in scholastic amusements."

Among the subjects taught in the

Preparation Branch were botany, practical mathematics, logic, rhetoric, and history; and the "scholastic amusements" included the collection and preservation of minerals, plants, and insects; the use of the microscope; drawing the internal structure of plants; making globes of plaster of Paris, and drawing maps upon them; land surveying; taking the latitude; simple hydraulic experiments; experimenting with gases; making and using galvanic batteries and magnets; constructing and using thermometers and hygrometers; taking specific gravities, etc. The circulars also contain, among other curious and interesting information, statements of the cost of tuition and of living.

The success of the school in its early days was largely due to the remarkable powers as a teacher, of its first senior professor, Amos Eaton. He introduced the methods of instruction outlined above, and many of his pupils who have since become eminent as scientific teachers and investigators bear testimony to the peculiar value of his teaching. He not only was successful as a teacher, but was well known as a popular scientific lecturer and as an investigator. The various editions of his textbooks on botany, zoölogy, chemistry, geology, and surveying, number in all about forty publications

In 1832, by an act of the Legislature, the name of the institution was changed from the Rensselaer School to the Rensselaer Institute; and by an act passed in 1833, the trustees were empowered to establish a department of mathematical arts, for the purpose of giving instruction in Engineering and Technology. This meant the establishment of a course in *civil engineering*. Although the inclusion among the duties of the senior professor, in the first triennial catalogue published in 1828, of lectures on civil engineering is significant of the enlightened views of the founder and officers of instruction, the institution had been to this time a school of *natural science*, its graduates receiving the degree A. B. (n. s.). It is to be remembered that at this time there were in this country hardly any engineers other than military engineers. The term "civil engineer" had scarcely been coined. The Erie Canal had only been begun in 1817, and the first

ONE OF THE MAIN DRAFTING ROOMS, RENSSELAER POLYTECHNIC INSTITUTE.

short piece of railroad was opened in 1830.

Eight members of the class of 1835 were graduated as civil engineers, and received the degree of C. E. This was the first class in civil engineering ever graduated in any English-speaking country. A circular entitled "Notices of Rensselaer Institute," dated October 14, 1835, gives the curriculum for students of civil engineering as well as for those of natural science. It is interesting as the first prospectus of a school of engineering ever printed in the English language.

To show the great difference between engineering education of that day and this, the requirements for degrees are quoted:

"The Rensselaer degree of Bachelor of Natural Science is conferred on all qualified persons of 17 years and upwards.

"The Rensselaer degree of Civil Engineer is conferred on candidates of 17 years and upwards who are qualified in that department.

"One year is sufficient for obtaining the Rensselaer degree of Bachelor of Natural Science or of Civil Engineer, for a candidate who is well prepared to enter. Graduates of colleges may succeed by close application during the twenty-four weeks in the summer term.

"The degree of Master of Arts is conferred after two years of practical application."

Prof. Amos Eaton died in 1842; and George H. Cook, of the class of 1839, who was afterwards widely known for his work as State geologist of New Jersey, was appointed senior professor in the same year. Under the direction of Professor Cook the school was reorganized and the courses of instruction somewhat extended. He resigned in 1847, and was succeeded by B. Franklin Greene, of the class of 1842, who became director of the institution when that office was created by act of the State Legislature in 1850.

Professor Greene's acceptance of the position marks an epoch in the history of the school. After a careful study of the scientific and technical institutions of

THE ALTERNATING-CURRENT LABORATORY.

Europe, the curriculum was, under his direction, thoroughly reorganized in 1849. This reorganization included a material enlargement of the course of study and the requirement of a more rigid standard of scholarship from candidates for degrees. The number of instructors was also increased; and the length of time devoted to the course was changed to three years, with a "Preparatory class" which made it practically four years in duration. The graduating or senior class was called Division A, and

to matters immediately cognate to architecture and engineering; that, moreover, for a somewhat irregular and for the most part optional course requiring but a single year for its accomplishment, they would substitute a carefully considered curriculum which should require at least fully three years of systematic and thorough training; and that, finally, they would demand the strictest examination tests to the successive parts of the course prescribed, not only in respect to the translation of students from lower to higher classes, but especially in all cases of ultimate graduation with professional degrees."

It was at the time of this reorganization in 1849-50 that the name RENSSELAER POLYTECHNIC INSTITUTE was first given to the school. This change of name was ratified by act of Legislature, April 8, 1861.

A SURVEYING PARTY IN THE FIELD.
A Typical Scene from Student Life.

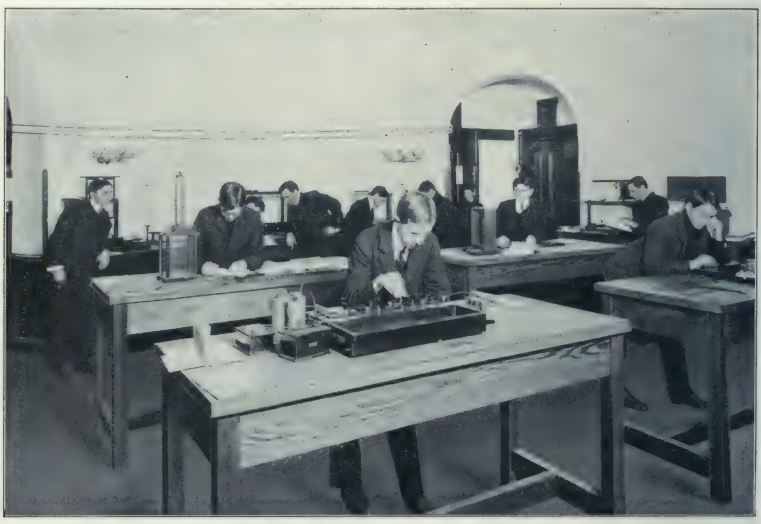
the others Divisions B and C. In 1858 the Preparatory class was merged into the regular course under the name of Division D. Professor Greene published in 1856 a pamphlet of 84 pages, entitled "The Rensselaer Polytechnic Institute; Its Reorganization in 1849-50; Its Condition at the Present Time; Its Plans and Hopes for the Future." This, as its title indicates, was descriptive of the reorganization. The following paragraph from it shows clearly the character of the changes and the intentions of the authorities:

"The managers of the Institute therefore resolved that their field should be narrowed and more thoroughly cultivated; that indeed their educational objects should be restricted

Thus were inaugurated the course and methods which have resulted in giving to the engineering profession in this and other countries during the last forty years many of its most distinguished members. The main causes of the reputation of the school and of the success of its graduates have been the method of instruction then adopted and the high standard of scholarship always maintained. Although the curriculum, of course, has since been changed from time to time, to adapt it to the needs of the best modern practice,

the methods have remained practically unchanged.

Classes are divided into small sections, and each student is required to recite each day in every subject. Textbooks supplemented with lectures and explanations,



TAKING ELECTRICAL MEASUREMENTS.

are used whenever the nature of the case permits. The students not only are interrogated, but in almost all subjects are required to make blackboard demonstrations. After the material constituting each term's work has been finished, a review in all subjects follows, and afterwards an examination. Close records of the work done each day are kept, and the success of the student in passing in any subject depends largely upon these daily records.

Each year is divided into two terms of about nineteen weeks each, and examinations are held at the end of each term. Besides this, students of divisions C and B, which correspond to the sophomore and junior years respectively of academic schools, go into the field during the month of July for instruction in practical surveying of various kinds. This is in addition to the surveying required during other parts of the course.

The principal course of instruction given is that in Civil Engineering, and the degree conferred is Civil Engineer (C. E.). It is to be distinctly understood, however, that the instruction is not narrowed to any special branch of civil engineering. The design of steam engines as well as that of bridges, sewerage systems, waterworks, etc., is taught; and the student receives instruction as well in the principles of Electrical Engineering as in the location and construction of roads and railroads. There is also given a course in natural science, upon the satisfactory completion of which the degree of Bachelor of Science (B. S.) is conferred.

The schedule of the course in Civil Engineering at the present time (1904) contains the following subjects:

FIRST YEAR.—*First Term:* Chemistry, Theory and Lectures; Algebra; French; Projections, Theory and Drawing; Freehand Drawing; Elements of Drawing; and Lettering.

Second Term: Trigonometry; Analytical Geometry, Plane; Mensuration; French; Surveying, Theory and Practice; Topographical Drawing; and Mechanical Drawing.

A thesis must be written during the summer vacation.

SECOND YEAR.—*First Term:* Analytical Geometry, Solid; Differential Calculus; Integral Calculus; Surveying, Theory and Practice; Chemistry, Qualitative Analysis; and English Language.

Second Term: Descriptive Geometry, Theory and Drawing; Shades and Shadows, Theory and Drawing; Perspective, Theory and Drawing; Surveying, Theory; Chemistry, Qualitative Analysis; Physics; and Freehand Drawing.

A thesis must be written during the summer vacation.

THIRD YEAR.—*First Term:* Surveying, Practice; Geodesy; Electricity, Theory and Laboratory Work; Machine Construction, Theory and Drawing; Road Engineering; Mechanics, Rational; Botany; and Map Drawing.

Second Term: Mechanics, Rational; Mechanics, Theory; Structures; Descriptive Astronomy; Railroad Curves, Theory; Metallurgy; Mineralogy; and Assaying.

A thesis must be written during the summer vacation.

A three weeks' course in Railroad Engineering practice is required during August and September.

FOURTH YEAR.—*First Term:* Resistance of Materials; Hydraulics; Sewerage; Bridges and Roofs; Spherical Astronomy; Economic Theory of Railroad Location; Stone-Cutting, Theory and Drawing; and Thermodynamics.

Second Term: Hydraulics; Hydraulic Motors; Bridge Design; Electrical Engineering, Theory; Electrical Laboratory Work; Steam Engineering; Geology; Water Analysis; and Law of Contracts.

A graduating thesis must be presented.

The studies of the course in Natural Science are identical with those in Civil Engineering during the first two years, and for the last two are as follows:

THIRD YEAR.—*First Term:* Chemistry, Qualitative Analysis and Quantitative Analysis; Physics, Measurements in General Physics and in Sound, Heat, and Electricity; Electrical Theory; and Shop Work.

Second Term: Chemistry, Quantitative Analysis; Physics, Measurements in Light; Descriptive Astronomy; Metallurgy; Mineralogy; and Assaying.

A thesis must be written during the summer vacation.

FOURTH YEAR.—*First Term:* Chemistry, Quantitative Analysis and Electro-Chemistry; Electricity, Electrical Measurements; and Thermodynamics.

Second Term: Chemistry, Quantitative Analysis and Water Analysis; Electricity, Electro-dynamics; Physics, Thesis Work; and Geology.

A graduating thesis must be presented.

The following description of the laboratories of the Institute will give an idea of the equipment in constant use in these courses:

Seven rooms in the Williams Proudfit Memorial Laboratory are used for work in electricity. The laboratory possesses an unusually complete set of generators and motors of the most recent types. Current is supplied from the circuits of the Troy Electric Light Company, both 500-volt direct current and 60-cycle alternating current being obtained from this source. The laboratory also obtains electricity from its own power plant. The power plant consists of two 75-horsepower Babcock & Wilcox boilers (one equipped with superheater), and two 25-K. W. direct-connected generators. One generator is engine-driven, and the other is driven by a Curtis steam turbine.

Two rooms are given up to testing generators and motors. The laboratory is equipped with all the necessary voltmeters, ammeters, wattmeters, frequency indicators, tachometers, Prony brakes, etc., for carrying on tests on all the machines at the same time.

The machines include one Westinghouse 7.5-K. W. 500-volt D. C. generator; one Edison 3-K. W. 110-volt D. C. generator; one D. C. arc-light generator; one Crocker-Wheeler motor-driven generator, for electrolytic work; one General Electric 7.5-K. W. 3-phase alternator; and one General Electric 7.5-K. W. 2-phase alternator and motor-driven exciter.

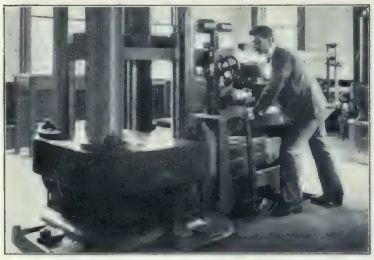
The motors include, in addition to several small motors, one Westinghouse 15-H. P. 500-volt D. C. motor; one Westinghouse 2-phase induction motor; and one General Electric 3-H. P. single-phase motor. Two series motors and controller, such as used in electric railway work, will be installed during the present year.

The equipment also includes one General Electric 7.5-K. W. motor generator, for converting 500 volts to 120 volts; and two Westinghouse 10-K. W. 60-cycle 500-volt rotary converters. The rotary converters are so arranged that they can be driven by motor as A. C. D. C. generators.

All the above machines are of the most recent types, and furnish the student with opportunities for becoming familiar with the most recent practice and with the various systems in use at the present time.

In addition to a complete outfit of primary batteries of the various standard types, the laboratory has a storage battery of the most modern type. This battery consists of 66 cells, each of 120 ampere-hours' capacity. The cells have chloride negatives and Manchester-type positives. The battery is especially useful in connection with photometric work and the standardization of instruments.

Two rooms are devoted to electrical and magnetic measurements. The equipment includes various types of Wheatstone bridges, galvanometers, condensers, a complete set of Reichsanstalt standard resistances, a DuBois magnetic balance, conductivity bridge, cable-testing set,



300,000-POUND TESTING MACHINE.

potentiometer, and standards of self-induction. Measurements of the candle-power, distribution of light, and efficiency of arc and incandescent lamps are made in the photometer room of the Physical Laboratory.

The equipment of the high-tension room consists of two General Electric 5-K. W. 2,200-volt static transformers; one General Electric constant-current floating-coil transformer with equipment of lamps; two Westinghouse 1-K. W. 2,200-volt static transformers; and two Westinghouse 10-K. W. 10,000-volt transformers. The equipment also includes induction coils and other necessary apparatus for experiments in wireless telegraphy and X-rays.

One room is given up to the shop. The shop is used in repairing and constructing apparatus for the laboratory, and for the instruction of special students in Electrical Engineering and of candidates for the degree of B. S. The equipment includes a 14-inch Hendey lathe, 15-inch Potter & Johnson shaper, Dwight slate sensitive drill, Northern Electric buffer, and forge. All the tools are motor-driven.

The laboratory has been equipped with a view to giving instruction to engineering students in the fundamental principles and modern practice of electrical engineering. At the same time the equipment includes all the apparatus necessary for carrying on original research or special investigations; and every possible facility will be afforded by the Institute to those desiring to take up any special work.

In the same building with the Electrical Laboratories, five rooms have been fitted up for laboratory work in Physics. Special rooms are fitted up for experiment and research in general physics, heat, light, and photographic and photometric work. The equipment of these rooms is very complete, including, in addition to the usual equipment, a cathetometer; dividing engine; astronomical clock; chronograph; standard barometer; two Becker and two Sartorius balances; special apparatus for measuring modulus of elasticity, modulus of torsion, and coefficient of expansion; Barus calorimeter; Chatelier pyrometer; Hilger spectrometer; Zeiss spectrometer; Rowland plane and concave grating; Schmidt & Haensch polariscope; Zeiss microscope; and Abbe refractometer. Gas and two electric circuits are brought to each table.

The photometer room is equipped with a Reichsanstalt photometer, and has all the necessary attachments for standardizing and measuring mean horizontal or mean spherical candle-power of arc and incandescent electric lights or other light sources.

The Chemical Laboratories are contained in two adjacent and connected buildings. These buildings contain ten rooms, and include a large lecture room equipped with facilities for lectures on general chemistry, two large main laboratories for qualitative and quantitative analysis, one small laboratory for special work, a laboratory containing the necessary furnaces and muffles for assaying, and a special laboratory for the analysis of water. There is also a library con-

taining special works on chemistry, and a recitation room. Besides these there are weighing rooms, and various closets and rooms for apparatus, carboys of acid, and the other equipments usual in chemical laboratories.

One of the main laboratories is equipped with the best modern appliances for qualitative chemical analysis. Each student finds in his working table the full set of apparatus required for his ordinary analytical work, and upon his bottle racks are forty chemical reagents for his sole use. Special reagents and apparatus are used in common, and are issued from the stock room upon individual application.

MAIN LABORATORY FOR QUALITATIVE ANALYSIS.

A special laboratory thoroughly equipped with chemical and bacteriological apparatus is provided for the examination of water, and is situated apart from the main chemical laboratories so as not to be exposed to the fumes found in them. Besides the routine work in water analysis, which is made a specialty at the Institute, investigations concerning the sanitary side of "water supply" and "water purification" are constantly in progress in this laboratory.

In the Laboratory for General Tests, there are installed one 300,000-pound and one 100,000-pound testing machine, which are driven by an electric motor; also one 50,000-pound machine with special extensions for long-column tests; and one 10,000-pound wire-testing machine. Tests of steel, iron, brass, wood, stone, brick, concrete, and other materials are made in tension, compression, shear, and bending.

The Cement Testing Laboratory is fully equipped for the most approved modern tests. Besides a new cement-testing machine, it contains slate tanks for briquettes and concrete blocks, a slate moist box, a boiling and steaming apparatus, a shaker for mixing cement and sand, moulds, sieves, needles, and one of

Bauschinger's micrometric extensometers. A standard rattler, driven by an electric motor, is used for testing paving bricks; and absorption, crushing, and bending tests are also made. All these testing laboratories are situated in the Williams Proudfit Memorial Laboratory.

Since the establishment of the Institute, students have come to it from forty-two of the States and Territories of the Union and from many foreign countries, including the Bahamas, Brazil, Canada, Chile, China, Costa Rica, Cuba, Ecuador, England, Germany, Honduras, Ireland, Italy, Japan, Mexico, Nicaragua, Peru, Porto Rico, Russia, Santo Domingo, Hawaii, Spain, Colombia, and Venezuela. An appendix to the Catalogue contains the addresses and occupations of each one of the alumni. The living graduates are at present at work in forty-five of the States and Territories of the Union and in nineteen foreign countries. In 1899 a pamphlet entitled "A Partial Record of the Work of Graduates of the Rensselaer Polytechnic Institute" was compiled from copies of the *Annual Register*. It gives the names and positions of those of the alumni whose pursuits could be easily classified. Even in this particular it is necessarily incomplete, and no mention is made in it of many who have attained eminence in various callings. This partial list contains the names of sixty presidents, managers, and superintendents, and one hundred chief engineers of railroad companies, steel and iron works, bridge companies, waterworks, electric companies, mining companies, sewerage systems, canals, etc. It shows that these men have helped to build and operate more than 150,000 miles of the railroad systems of North America alone, and that they have been connected as designers and constructors with all the important bridge companies and the building of nearly all the great bridges of the country.

Skilled Labor in Demand

The Observations of a Railroad Official on the Problem of the Unemployed

FREDERICK D. UNDERWOOD, President of the Erie Railway, made a statement a few weeks ago which has caused him no end of trouble. In the course of an interview he remarked that his road would soon begin vast improvements, and that he could give employment to a thousand men. Since the interview was published, Mr. Underwood has been flooded with applications. To make the matter clear, Mr. Underwood publishes the following:

"When I announced that I could give employment to a thousand men I failed to mention the fact that I wanted skilled labor. I have been overwhelmed with letters from men who know no trade, but feel sure that they have general ability. That is the trouble—the country is filled with half professional men who know a little about a great many things, but do not know any one thing thoroughly. They have no fundamental knowledge, no practical training. They are, in a sense, non-producers.

"When business is dull it is the unskilled man, the non-producer, who is discharged first. When there is a place at the top vacant, it is the man of special knowledge, not the man of general knowledge, who is promoted. The man who wants to be a broker between the owner and the producer—and that is a striking American characteristic—has a difficult and insecure road to travel.

"Now, here is the Erie Railway about to begin vast improvements. I casually mention the fact that I would employ a thousand additional men if I could get them. Hundreds of applications for work come in by mail. From skilled men who would be useful in the work we have to do? No. Nearly all the letters are from men who are fit only for clerks' work, and not very fit for that either. That fact in itself shows that it is the untrained, not the trained, who are walking the streets in idleness and want."

Opportunities in the Electrical Field

Extracts from a Paper Read before the Western Society of Engineers, Chicago, March 18, 1904

By GEORGE A. DAMON

THE electrical business is a complicated one, and is constantly undergoing changes. By the time a method or system becomes standard enough to be looked upon as a precedent, a tendency develops in some entirely new direction. The men who succeed in electrical work must therefore be quick to grasp the lessons of the past, must be ready to appreciate the limitations of the present, and above all should be alert to seize the opportunities for improvement.

The leaders in the various branches of the industry during the first developments when electrical work was an art and not a science, were graduates from the well-known university of "Hard Knocks." The men of the second generation of workers who are now doing things are largely the product of a semi-scientific training in schools of technology, supplemented by experience of a practical nature picked up in a more or less haphazard way. A few years more will see the development of a third and better-prepared generation of electrical experts, and it is safe to say that they will be the result of a combination of practical training thoroughly mixed with theoretical education. As it must be expected that the next generation will be superior to the present one, will it not be well to stop for an instant in the strenuous rush for results, and make a few suggestions which may be of assistance to our successors in planning their life work?

"Work harder," "dig deeper," "put in a better cement foundation," are the keynotes of the suggestions which our older brothers give us as the result of their experience; and the ambitious young man will be quick to recognize the value of their advice. But what is wanted most is some definite information as to how to spend the time devoted to preparation in the most efficient manner, and how to get the benefit of a combined training in theory and practice in the most effective way.

That those who have traveled well on their way toward their goal have many opportunities to point the way to the ones behind, is well indicated by recounting a recent conversation with a boy of eighteen.

"I am a senior in the High School," he said, "and I want to become an electrical engineer; what shall I do?"

He was strong, bright, ambitious, and willing to work.

"Some men tell me to take a college course first, and enter practical work afterward; some tell me to get a few years' experience first, and then take a college course; while still others tell me to study several years, work a year or two, and then finish my senior year. In planning my course, should I include the language studies, or cut them out in favor of shop, laboratory, or commercial courses? Should I try to get through in three years, or should I extend my college education over a period of five years? Others tell me to leave out the university work entirely, go to work in the shop or upon construction work, getting what theoretical training I require by attendance at night school or by taking a correspondence course. What shall I do?"

And there are some of us who will appreciate the young man's bewilderment.

Knowing that the leading electrical men of Chicago would afford a valuable field for studying results and would welcome an opportunity to help furnish a solution for the problems of the boy, a letter of enquiry was sent to one hundred of the leading men in Chicago engaged

in the various branches of the electrical industry. An opportunity was given at the same time for the expression of opinion on various questions pertinent to the general subject. The response to the circular letter was hearty and spontaneous; and we are under obligations to one hundred of our friends who have so kindly consented to become living examples, and who are willing to be analyzed for the good of the cause. The following is an analysis of results:

Young men control the business. The enquiry was, therefore, confined to men between the ages of twenty-seven and forty-five, upon the theory that the older men are the product of a set of conditions which have passed away, while the youngest men are, as a rule, still engaged in a period of preparation. The average age is 33½ years.

The average income at each age shows an earning of $2,170 at twenty-seven, and this increases to $4,000 at the age of thirty-eight. The average income of the entire one hundred men is $3,440 per year, which will give us a standard by which we can measure the different branches from a mercenary standpoint.

The hundred men may be divided into groups as follows:

	No. of Men.	Average Age.	Average Income.
Salesmen	7	33	$2,400
Sales managers	11	36	3,400
Business men	10	36	4,800
Sales engineers	8	35	2,350
Electrical engineers	16	33	2,800
Constructing engineers	6	33	2,850
Electrical experts	8	33	3,200
Operating engineers	3	32	2,250
Operating managers and superintendents	10	34	3,550
Professors and editors	8	34	2,500
Patent attorneys	4	32	4,000
Consulting engineers	9	40	6,400

Total number of men, 100. General averages: Age, 33½ years; income, $3,440.

Classified in reference to incomes, the record is as follows:

	No. of Men.
Income over $10,000 per year	5
Income between $5,000 and $10,000	9
Income between $2,400 and $5,000	66
Income below $2,400	20
Total	100

It should be stated that there are in Chicago at least one hundred more men in the business whose incomes will average about the same as the first hundred selected. An effort was made to make the list representative, and the men were selected on account of their positions without reference to their incomes.

It is to be understood that the dollar is not the most desirable standard by which to measure men individually; but looked upon as a class, a study of the averages furnished by the enquiry is interesting and may be made instructive.

Salesmen who have technical ability or possess engineering information, as a rule, get better salaries than those who do not. Add initiative and executive ability to the salesman's qualifications, and he becomes a sales manager with a still greater reward. Enterprise and energy put the man in possession of his own business, or often result in a partnership arrangement. A technical man without the commercial instinct is only fairly well paid. Ability to develop new methods or apparatus puts him in the expert class where the rewards are greater, and in proportion to his ability.

Routine work, such as operating, is the least remunerative work of all. Operating managers and superintendents, however, are very well paid.

The phenomenal development along all electrical lines, and particularly in the telephone business, makes the profession of patent attorney a paying one for those who are qualified for that kind of work.

The field of consulting electrical engineering looks attractive; but it will be noted that the average age is greater in this branch than in the others, which means that the successful consulting engineer brings to his work years of experience, and that it is therefore not a branch to be adopted at once by the young man.

Forty per cent of the men in the list are employed by what might be termed the "large" companies.

Thirty-five per cent of the men either control the business in which they are engaged or own a partnership interest.

Twenty per cent of this hundred successful men never had any college education whatever.

The average age of the twenty men

who are succeeding without a college education is thirty-six years, and their success measured by a monetary standard shows an income of $3,670 per year.

It will be noted that the twenty men without the education are getting along financially slightly better than the general average of $3,440 per year. This is explained by the fact that in their number are included several men who are prospering as a result of their business enterprise.

There are few non-technical men engaged in the strictly technical end of the business who reach the average income. There seem to be more openings for the man without a college training in the telephone field than in any other.

Each of the hundred men included in the enquiry was asked to name the three fields which he considered most promising within the immediate future, and the votes received were as follows:

Electric railway work	63
Telephony	36
Transmission	30
Electro-chemistry	29
Power applications	21
Lighting developments	12
Manufacturing	11
Central station work	9
Patent law	6
Consulting engineering	6
Contracting	5
Management of properties	5
Storage batteries	4
Reconstruction of plants	3
Mining	3
Metallurgy	3
Turbines	2
Wireless telegraphy, designing, high-speed telegraphy, underground-conduit construction, isolated plants, train lighting, and municipal lighting, each	1

Practical experience is as essential as theoretical training. Too little attention has been paid by students in getting into thorough contact with the way things are actually done. This is the result of the general practice of allowing the young man to shift for himself. "I can't get a job without experience," he says, "and I can't get experience without a job;" and then, more or less discouraged at the outlook, he takes the first opening which presents itself, and it may or may not be the kind of work for which he is fitted. What is needed is a general clearing-house of information, a closer union between the ambitious student and the successful men who have been pioneers in the work. The electrical business has now progressed so far that the actual experience essential for the highest success along any one of its various lines can be generally indicated by experts familiar with the ground to be covered. It is time, therefore, to abandon a thoughtless and perhaps selfish attitude toward the beginner, and make some organized effort to map out the territory which he must travel with guide posts and signs marked: "This way to the front."

An association of thoroughly successful men should exercise some supervision over the preparation of the coming generation. If it is true that the art is suffering to-day from lack of trained men ready to take up and solve the problems which are all about us, what must we expect of the morrow with its widening opportunities? The student branches of the American Institute of Electrical Engineers and the recently-formed Edison Medal Association are moves in the right direction, but only a beginning toward realizing the possibilities. Considerable attention is being given to develop the best technical course, but a college training is less than half of an education. What constitutes the other half is a big problem waiting for a comprehensive answer.

The trouble with a great many young men is that they don't "find" themselves early enough in life. They fail to realize the possibilities, and are not prepared to grasp their opportunities. Ambition, aptitude, preparation, and hard work are the stepping-stones to successful attainment. Let the ambition to excel be deeply seated, and directed along the line of natural endowment; let the purpose be firm; and, as day follows night, the preparation will be thorough and the man will be known by his works. "If I had it to do over again I would pick out some definite line of work suited to my talents and work like fury" is the advice of many successful and even unsuccessful men.

The purpose of this paper is to encourage a general discussion, which may be of some help in arousing the latent ambitions of the young men who have not selected their life work, by showing them the boundless opportunities of an undevel-

oped science; to encourage the efforts of the students in our colleges by presenting the results which have been attained by their predecessors; to crystallize the sentiment in favor of a scientific combination of theory and practice; and, finally, to give an opportunity to the men on the fighting line to point the way to their successors, who must come to the front prepared in every way if they intend to take some part in the phenomenal developments which are to be expected.

In order to direct the discussion along definite channels, the following is offered as a suggestion to a young man seriously considering engaging in the electrical business:

In General—The purport and intent of this specification is to cover the labor and material required to produce in complete working order a man prepared to attain his own ideal of success in that branch of electrical work which he may elect.

It is to be understood that the omission of the mention of small details in this description does not obviate the necessity of their being furnished. What is wanted is a thoroughly trained, well-seasoned, broad-minded man, complete with an individual character, a strong intellect, and a sincere purpose.

Plans—He will form his ambition early in life.

He will take a natural interest in the history of men of eminence in his chosen work, and their achievements will inspire him with a desire to accomplish great things.

He will develop his imagination, and constantly broaden his conception of his own possibilities.

He will seek to learn what the world wants, and then will endeavor to train his natural abilities so as to supply that want.

Foundations—He will as a boy develop a knack of "doing things" either as a mechanic, as a draftsman, or in some boyish business enterprise; and a combination of any two or all three proclivities is desirable.

He must early learn the advantage of doing some one thing well; but he should not allow praise for his proficiency to encourage him to neglect study along the lines he does not naturally fancy.

He will not let the attractions of practical work interfere with his intentions to secure the best theoretical and technical training the country affords.

General Design—Each bidder will state the percentage which he is prepared to guarantee in connection with the following qualities:

Health	Patience
Ambition	Cheerfulness
Honesty	Self-respect
Truthfulness	Self-reliance
Temperance	Courage
Self-control	Observation
Decision	Initiative
Purpose	Enterprise
Up-to-dateness	Enthusiasm
Originality	Concentration
Energy	Executive ability
Common sense	Scholarship
Industry	Despatch
Tact	Punctuality
Grit	Stick-to-itiveness
Thoroughness	Judgment
Neatness	Good manners
System	Capacity for hard work

Capacity—Even if the young man possesses only ordinary talents, his capacity for hard, conscientious, intelligent, well-directed work will attract attention and win advancement.

When the occasion demands, he will be able to stand a long run on overload, or respond to excessive demands for short periods, without permanent injury.

He will be able to direct others, and will not depend entirely upon his unaided efforts for results.

Operation—He will work quietly, and will be turning in the right direction every minute in a simple, direct, and accurate way.

He will join that great army of workers who are actually doing things, rather than that smaller class of men who occupy most of their time in telling what they are going to do.

He will make friends among his superiors, who will respect his ambitions and will be glad to assist him in realizing his ideals.

He will study men and know how to deal with them.

Work to Be Done by Others—Parents should study their children and encourage them to develop their natural tendencies.

More occasions should be made for successful men to meet students and give them the benefit of their advice and experience. The students should not be isolated in a little world of their own, but should be brought in contact with an atmosphere of actual affairs.

Shop Tests—If he enters the shop or testing department of a manufacturing company, he will make a bargain which will result in his getting an all-around experience in exchange for his services, and while in the shop, will keep "on the move" in every sense of the word.

He will seek to make himself thoroughly practical in all his ideas and methods of work.

Fittings—He will find it necessary to possess accurate knowledge of nearly every branch of science, including physics, chemistry, mathematics, mechanics, pneumatics, hydraulics, mining, metallurgy, and civil engineering.

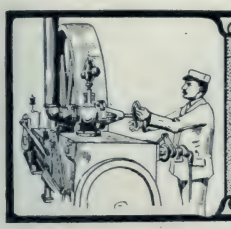
He must know something about accounts, and a great deal about business and commercial law.

He will find that the electrical business is so broad in its scope that a natural aptitude in any direction can be made of use.

Completion—He will make every sacrifice to get a thorough preparation and a broad experience up to the age of twenty-eight or thirty years.

He will accomplish much between the age of thirty and forty-five, at the end of which time he will be well settled in his business or profession.

Let us leave him at this time to inherit his own. May he live long and prosper!



ENGINEERING NOTES

LONGEST TRESTLE IN THE WORLD

ON Thanksgiving Day, 1903, occurred an incident ranking in importance with any previous event in the history of American transcontinental railroads. This was the completion of the track of the Southern Pacific Railway System across Great Salt Lake in Utah. The circuitous old route around the northern end of the lake, between Ogden on the east and Lucin on the west—a route marked by heavy grades and curves—is now avoided by a direct line running almost due east and west between these two points. The construction of this "cut-off" is classed by some experts as one of the most difficult engineering feats ever accomplished in this country.

The new line, which is described by Mr. Bruce Kinney in a recent number of *The World To-day*, crosses 8.03 miles of the lake; runs four miles across the southern extremity of Promontory Peninsula, which extends southward half the length of the lake from the northern shore; then runs 19.45 miles across the lake again to the west shore.

The main object in the construction—which involved an expenditure of something like $5,000,000—was to gain time in the transcontinental journey. Untold millions have already been spent in the solution of this problem. Rolling stock and motive power have been improved. Distances have been shortened by reducing grades and curves. To this end mountains have been tunneled or cut down, and valleys filled. In the last three years various roads have spent more than $12,000,000 in reconstructive work in Utah alone. This reduces operating expenses, lessens the danger of accidents, but, most important of all, decreases running time. This means increased passenger, freight, and mail traffic, for which these roads get as much pay as their rivals, but which costs them less to carry.

The method of construction in the "Ogden-Lucin cut-off" is trestle-work. It is the longest trestle in the world, that

A TRAIN CROSSING THE TRESTLE

of Lake Ponchartrin, near New Orleans, La., coming next with seventeen miles. The trestle stands about eight feet above water, and is made of piles averaging 125 feet long and driven down in pairs fifteen feet apart. Each pair is properly braced, and is connected by heavy cross-pieces and stringers on which the ties are bolted. These ties carry the heaviest steel rails. Flooring is laid under the stringers, and the space above filled with gravel, while the sides are banked with broken rock. From either shore temporary trestle was

constructed until a depth of about thirty feet was reached. This was filled with rock and gravel. In deeper water a permanent trestle was built. There are 11.84 miles of temporary, and 11.10 miles of permanent, trestle. In the work of construction, seven tug boats, a stern-wheel steamer, numerous smaller craft, several locomotives, and 200 specially built steel cars were used, and about 6,000 laborers employed.

PORTION OF THE SOUTHERN PACIFIC RAILROAD TRESTLE ACROSS GREAT SALT LAKE, UTAH.
View Looking Westward.

One of the great difficulties was in the storms which arose on the lake, destroying temporary work and carrying off thousands of valuable piles. Another difficulty lay in the fact that in some places the bottom of the lake was a quicksand which several times swallowed an embankment, track, and cars. Then more mountains of rock would have to be dumped in. No doubt the roadbed is perfectly safe now, for a locomotive and twenty loaded cars, each weighing more than 100 tons have been run across repeatedly. Such a train weighs much more than any passenger train.

The former distance between Ogden and Lucin was 146.68 miles. It is now 102.91—a saving of 43.77 miles. The new route saves 3,919 degrees of curvature and a vertical grade of 1,515 feet. The line is practically straight and level, the sharpest curve being one and one-half degrees, the steepest grade twenty-one feet to the mile, and the entire distance only .32 of a mile longer than air line. At Salt Lake City, tourists have had to take a round-trip journey of thirty-six miles just to see this unique lake. They will now travel over twenty-three miles across the water, having an unobstructed view on either side.

While the cost was very great, the management claims that the saving in operating expenses would pay the interest on a sum five times greater. There are all the other advantages thrown in.

This gigantic piece of engineering was practically completed in eighteen months from the time the first material was delivered at the lake. The trestle is surmounted throughout its entire length by a breast-high hand rail.

A CONCRETE LOCK AND DAM

MR. CHARLES W. MANN, an Inspector in the United States Engineering Department and a student in the American School of Correspondence, has sent to THE TECHNICAL WORLD an interesting description of an extensive piece of gov-

ernment work on the Kentucky river—the construction of a concrete lock and dam, one of those designed to facilitate navigation of the upper waters of that important stream. The following is Mr. Mann's description:

Lock and Dam No. 9, as the number implies, is the ninth lock in a series necessary to make navigable the Kentucky river. It is situated near the hamlet of Valleyview, Madison county, Kentucky, 157 miles from the mouth of the river.

With the exception of the guide cribs, the construction is of concrete, with steel gates and accessories.

DAM AND LOCK No. 9 ON KENTUCKY RIVER NEAR VALLEYVIEW, KENTUCKY.
Showing Triangular Cribs, Guide Cribs, and Lock Walls.

The guide cribs are of 10-inch by 10-inch yellow pine, spiked together with ¾-inch drift bolts and filled with stone. The upper land crib rests on a foundation of piles, driven to bed rock, while the lower cribs have a foundation of concrete.

There are also two triangular cribs, on river side, at the upper end; these have a foundation of concrete to the elevation of the upper pool, and timber tops filled with stone.

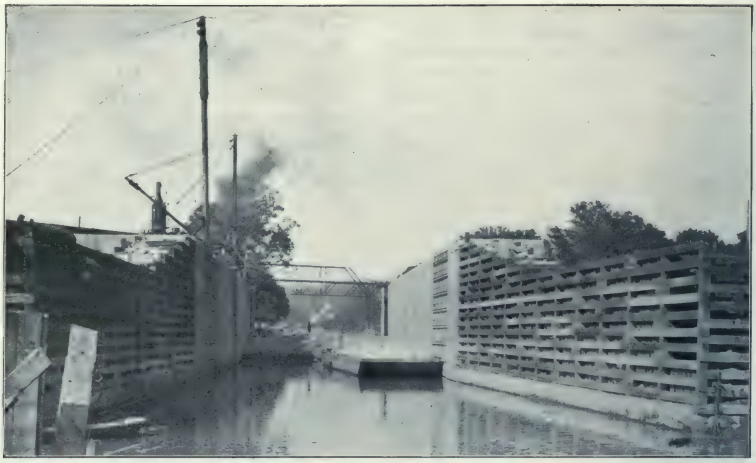
The walls of the lock are 246 feet long, with an available length of 150 feet in the lock chamber; width of chamber 52 feet; length of guide cribs 200 feet; length over all 446 feet.

At the upper gate anchorage the lock walls are 23 feet thick at the foundation, and 17 feet thick at the top; at the lower anchorage, 25 feet at the foundation, and 17 feet at the top. For a distance of 125 feet in the center the walls are 22 feet thick at the foundation and 6 feet at the top.

The lock is operated by means of four cylindrical valves, two at each end, set in recesses just above the bearing points of the gates. These valves are connected with culverts, which pass through and empty at the lower side of the miter walls; they are operated by hand, the necessary machinery being placed in a recess and connected with a winch on top of the wall.

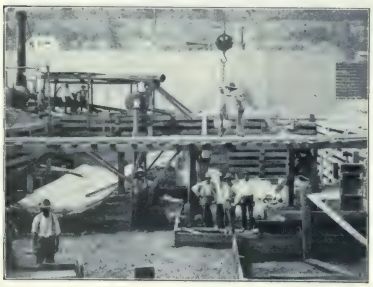
Each gate is composed of two leaves. The upper ones are 29 feet long and 20 feet high, weighing about 37,000 lbs. each. The lower ones are 29 feet long, 34 feet high, and weigh each about 72,000 lbs. They are operated by rack and pinion.

In general the walls are constructed of blocks, or monoliths, 33 feet long, and from 7 to 10 feet thick.



WALLS AND CRIB STRUCTURE, LOCK No. 9, KENTUCKY RIVER.
View taken during Progress of Construction.

The dam, including abutment, is 247 feet in length along the crest, and 33.5 feet high in midstream; it is 34 feet wide at the foundation, and 5.5 feet wide on top. It was built in four courses, the blocks being from 30 to 34 feet in length. At the highest point the weight is approximately 57 tons per linear foot. Both lock and dam rest on solid rock foundations.



TYPICAL VIEW DURING PROGRESS OF CONSTRUCTION WORK.

The lift, or difference in elevation of upper and lower pool, is 18 feet. This furnishes slack water to Ford, Ky., which is 19 miles above, where a similar lock is under construction.

The approximate quantities of material used are as follows:

Concrete	21,800 cub. yds.
Iron and steel	243,300 pounds.
Crib timber	188,000 ft., b. m.
Coffer-dam timber	400,000 ft., b. m.
Drift bolts	38,000 pounds.
Ballast or crib filling	4,500 cub. yds.
Piling	1,000 lin. ft.

Both lock and dam were designed by Major H. F. Hodges, Corps of Engineers, U. S. A., and were constructed under the direction of Lieut.-Col. E. H. Ruffner, Corps of Engineers, U. S. A. The contractors were The Sheridan-Kirk Contract Company, of Madison, Indiana.

Work was begun June 1, 1901; and at the present time (April, 1904) the lock is in shape to be used, a few minor details remaining to complete the work.

LACKAWANNA R. R. FERRYBOATS

AN incident marking a distinct advance in railroad ferry service in America was the recent awarding of a contract to the Newport News Shipbuilding & Engine Company for the construction of four steel, double-decked, screw ferryboats to be operated in connection with the 23d Street (New York City) ferry of the Lackawanna

Railroad. As in the designs for the ferry terminal, no expense has been spared in the plans for this new steamer equipment.

The new boats will have a length of 231 feet, a beam of 62 feet, a draft of water of 10 feet 6 inches. The steam will be supplied by two Scotch boilers for two sets of compound engines, the horsepower being 1,400, and the speed 14 miles an hour.

The plans show a boat considerably larger than the largest ferryboats now operating on the North river, designed with special reference to handling large crowds comfortably, and making regular trips through conditions of storm and ice. Special attention has been given to the subdivision of the hull by water-tight bulkheads, so that in case of collision the safety of the public will not be endangered, and the boats will have the strongest construction ever used in ferry service in New York, additional security, in the event of collision, being secured by means of specially designed steel bows.

The general finish of the interior will be in the Colonial style, with mahogany seats, stairs, and trim, and white paneling. The floors of the cabins will be covered with a form of rubber tiling. Special attention has been given to lighting, so that by day or night a passenger will be able to read a newspaper in any part of the cabins. The lower cabin will be finished with a system of cross-seats on the inner side, and an attractive arrangement of arches making an effect especially attractive; and a special form of electric lighting will be used, giving an even and diffused light. The upper cabin will also have mahogany and white finish, tiled floor, and a large seating capacity arranged so that in the whole boat one thousand passengers can be accommodated without crowding.

The boats will be heated and ventilated by an indirect hot-air system, the fresh air being carried through heaters placed below decks, and forced into the cabins from above through concealed ventilating ports, thus assuring not only warmth but fresh air in the extreme conditions of winter cold. More window space has been given than in the present boats, and in every way the comfort of the traveling public has been completely provided for.

The plans were furnished by Gardner & Cox, working in consultation with Colonel E. A. Stevens of Hoboken, N. J.

By this addition to their fleet the Lackawanna Railroad is simply living up to the traditions of the Hoboken Ferry Company, now owned by them, which, it will be remembered, was the originator of the present type of double-end, screw-propelled ferryboats, now adopted as the standard of ferry service in America.

NEW LACKAWANNA RAILROAD FERRYBOAT CROSSING THE NORTH RIVER

THE STROBOSCOPE

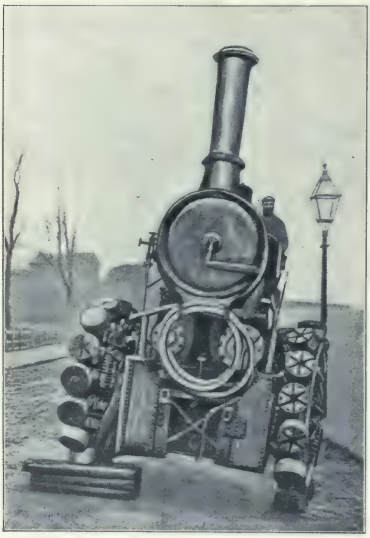
A Device for Magnifying Time

THE above descriptive sub-title is really a misnomer—for time cannot be magnified any more than can space. But just as it is possible for the microscope to project upon the retina impressions that render objects visible which are really invisible to the naked eye, so it is possible by mechanical means to reproduce at moderate speed successive views of an object which is moving so rapidly that it cannot be seen

by the unaided vision. An instrument devised for this purpose was recently described before the Institution of Electrical Engineers, London, Eng., by M. Hospitalier, a Frenchman, president of the *Société Internationale des Electriciens*. It is known as the "Stroboscope."

In the case of a rapidly revolving wheel, for example, the spokes appear a mere blur or wholly invisible to the eye. The stroboscope, however, enables us to realize the exact appearance of the moving object at a definite instant in its progress. By this means a movement that really takes place in a hundredth or a thousandth of a second may be seen drawn out to a quarter of a minute or more. The time of the movement is, as it were, magnified so as to enable it to be watched and examined at leisure.

The instrument that produces this wonderful result is almost ludicrously simple when one understands its principle. By



PEDRAIL ENGINE TURNING A CORNER OVER AN OBSTACLE

means of electric sparks fired at rapidly recurring periods, or a revolving disc with slits passed before a lantern, the moving object is illuminated in a succession of flashes. If the flashes coincide exactly with the period of the machine's revolution, they will show it always in one position, and to the observer it will seem at rest. By slightly retarding the flashes, so that they lag behind their time, the machine under observation will seem to move slowly, because at each revolution it is shown at a slightly later stage. Thus a movement too rapid for direct observation may be analyzed and watched slowly, the strains or vibrations at every point being clearly noted. You may, for example, watch the formation of the stitch in a sewing machine, the exact way in which a gasoline motor works, and a thousand other machine movements where it is important to see slowly what goes on with lightning speed. The great glare of the arc lamp is not a continuous light, but the see-saw of an alternating current, so fast that the eye cannot catch the rise and fall of the illumination. The stroboscope will throw the image of the arc and screen so that the rise and fall of the light appear quite slow, and the effects of different kinds of carbons, different frequencies, and different methods of regulation can be judged.

The stroboscope principle has many applications, being used in the *ondographe* (wave recorder) and *puissancegraphe* (power recorder), by which electric currents of immense rapidity can be studied and the exact nature of their periodic action determined and recorded.

A WALKING LOCOMOTIVE

A Description of the "Pedrail," an Interesting Device—Half Traction Engine and Half Walking Machine

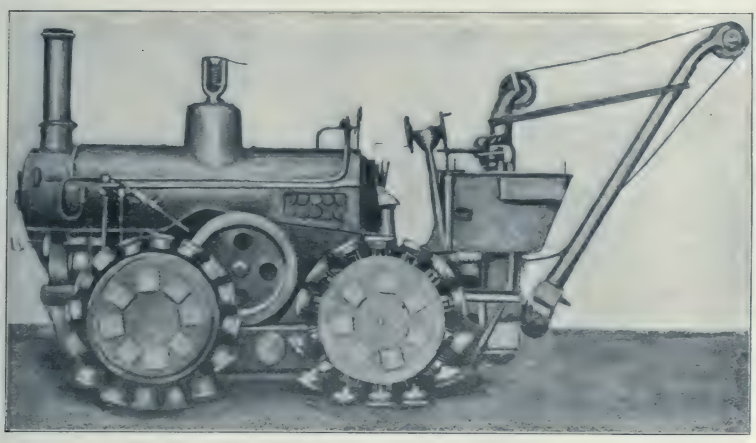
By J. Boyle
United States Consul at Liverpool, Eng.

FOR some years past, Liverpool has been in the forefront in scientific study and practical experiments on means of road haulage of freight. Contests of motor wagons are held here yearly under the auspices of the Self-Propelled Traffic Association, of which the Earl of Derby is the president. The amount of heavy haulage in Liverpool from the ships and docks to local warehouses and railway stations, is probably greater than in any other city in the world, and is a serious item in the cost of goods. Then, railroad

freight charges in England are enormous —from two to six times as much as in the United States. Consequently, there is always great interest in this city in any invention or system which promises to reduce the cost of haulage.

Professor Hele-Shaw, of the Engineering Department of the Liverpool University, is admittedly one of the greatest living authorities on mechanical locomotion; therefore his unequivocal and enthusiastic indorsement of a new invention called the "pedrail" has attracted wide and respectful attention in England, not only among the general public, but among scientific engineers. Professor Hele-Shaw recently gave an address before the Liverpool Self-Propelled Traffic Association on the pedrail, illustrated by models, drawings, and cinematograph pictures. Had the door spaces in the university lecture hall been wide enough and the floors strong enough, the professor would have had a pedrail for actual demonstration. He asserts that it was quite possible for it to have climbed up the steps and walked into the hall.

The pedrail is variously described as a "walking locomotive," a "half traction engine and half walking machine," a "combination of an endless railway and a trotting machine," and a "rail moving on wheels." The *Automotor Journal* of London describes it as "a traction engine which actually and literally walks up stairs with the stride and sure-footedness of an elephant, and hauls loads behind it under circumstances which would nonplus an ordinary traction engine. Ruts, curbstones, and bowlders it makes nothing of, and even 9-inch balks of timber are stubble before it." The inventor is Mr. Bramah Joseph Diplock, of London. Professor Hele-Shaw says that he had some years since conceived the idea of a locomotive with rails moving around the wheels. He encountered difficulties which to him seemed insuperable; but these difficulties, he asserts, Mr. Diplock has surmounted. The professor declares that the pedrail is "a revolution in mechanical locomotion."

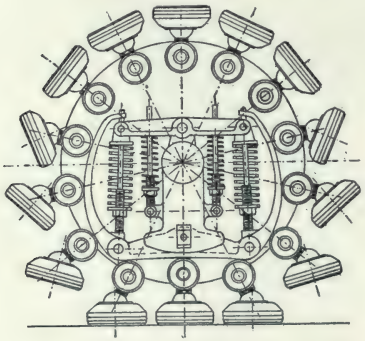


AN ENGINE MOUNTED ON FOUR PEDRAILS

The pedrail, it is claimed, can be used with advantage not only for ordinary freight haulage on common roads, but is thoroughly practicable as a traction engine over bad roads, and even in districts where there are no roads at all, and where progress by the ordinary traction engine would be absolutely impossible. The machine would, for instance, as claimed, be suitable for hauling minerals from newly developed mines, and heavy lumber from partly cleared forests, and would successfully meet the rough emergencies of military operations.

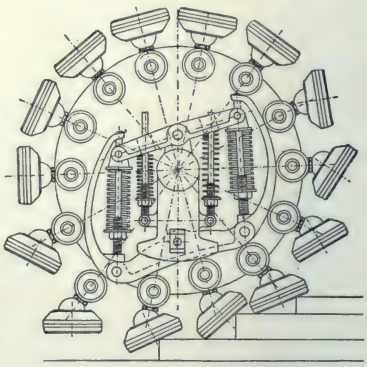
While Professor Hele-Shaw is convinced, after an intimate and close study of road locomotion and the properties of the wheel for many years, that no contrivance can take the place of the wheel and the pneumatic tire in circumstances where the road service is good and the conditions suitable, he is also convinced that the wheel itself has reached its utmost limits of carrying power, in regard to both weight and speed upon the ordinary roads, however well the roads may be constructed or however perfectly the wheel may be made. He argues that many great inventions are imitations of the working of nature itself, and he cites the screw propeller as being an exact reproduction of the action of a fish in swimming; but because the motive power of the propeller has to be of a rotary nature, the continuous revolution of the screw is substituted for the intermittent action of the fish's tail. Screw propulsion, the professor adds, may be said to have solved the great problem of ocean navigation.

Professor Hele-Shaw submits this question: Is there in use a means of locomotion on land imitating successfully the marvelous natural process of



SIDE VIEW OF PEDRAIL, SHOWING RAILWAY

animal locomotion, but modified to suit the mechanical requirements of the case? The wheel, he says, falls hopelessly short of the mechanical action of an animal's foot. The animal does not turn upon its foot; the turning takes place upon the ankle, which, being flexible, and having a ball-and-socket joint perfectly lubricated, affords the very minimum of resistance. The foot is placed upon the ground and kept there, thus ensuring the minimum of rubbing action with the surface; whereas the wheel is only adapted to turn on the surface of the ground



SIDE VIEW OF PEDRAIL MOUNTING STEPS

itself. Second, while the wheel, when it strikes an obstacle, meets with bodily resistance, the foot can be brought down upon an obstacle and the body elevated over it gradually with the least possible amount of shock.

Such considerations have naturally suggested the invention of walking machines. These inventions have all been failures, and principally so because they have not combined satisfactorily the adapting of the movement of an animal —which is intermittent—with the continuous movement afforded by the properties of the wheel. In the belief of Professor Hele-Shaw, the solution of the problem is the pedrail, which is described by him as follows:

The pedrail indicates by its name that it is a rail carried upon feet; and the principle of its action may be explained in a few words. It is simply this: Instead of having a permanent rail carried for the whole of its length on permanent feet (*viz.*, sleepers) and wheels running upon this rail, the process is inverted. The feet are (as in the case of the railway) placed upon the ground; but instead of the rails being carried upon the feet, these feet support wheels, and the wheels thus supported act as bearers for a short length of rail attached to the moving carriage.

The fundamental idea itself is not a new one. You may see in many timber yards that the logs are moved about by being pushed over supports which carry wheels, and by shifting these supports from place to place the heaviest logs of timber can be rolled upon the wheels to any required part of the yard. The pedrail invention, however, does more than this. The feet and wheels which they support are attached to the moving carriage itself, so that by an automatic process the feet are carried round after the rail is moved over them, and placed again in front of the machine, thus affording a continuous track of wheels upon which the supporting rails can be carried in any direction in which the vehicle is steered.

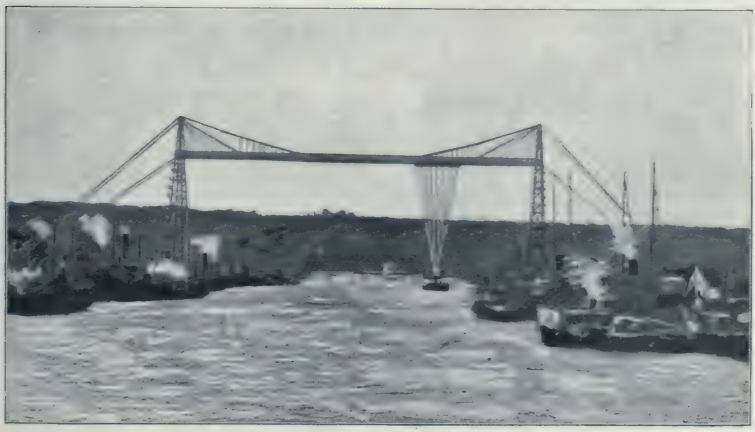
Briefly, the invention might be described as replacing the wheels of an ordinary traction engine by revolving frames carrying sliding spokes, each spoke having at its end a circular foot, and on the spoke itself, at a little distance above the foot, a small wheel or roller. In connection with each series of revolving spokes, a fixed frame is attached to the side of the traction engine. This fixed frame somewhat resembles in form an inverted heart. When the axles revolve, the spokes are carried round, and in turn place the feet upon the ground. At the same time, the wheels, which run round in contact with the heart-shaped frame, when brought underneath it—that is, under what may be described as the broader portion of the heart—act in turn as supports for the heart-shaped frame to glide over. Hence the engine is itself supported in turn, through the wheels, by the spokes which happen at the time to be resting with their feet upon the ground.

The pedrail consists of two main parts—one part being the railway which is fastened to the axle box and which does not revolve, and the other part a kind of circular box carrying sliding spokes, rollers, and feet in such a manner that the rollers and feet are placed in succession on the ground, and the rail runs over them. It has attached to it a 4-ton crane, so that it can lift and carry heavy goods, minerals, or agricultural produce.

"This engine," says Professor Hele-Shaw, "I have myself tested at Stoke-on-Trent under the most trying conditions. I took it up the steepest hill—practically a mountain—which I could find in the neighborhood; threw down large stones in its path, over which the feet simply set themselves at an angle and did not crush them, though the wheels of a heavy traction engine immediately crushed and distorted the road surface. I made this machine walk over a 3-inch, then a 6-inch, and finally a 9-inch balk of timber thrown down in its path; and I could scarcely believe that the whole structure was not permanently distorted and damaged, whereas it was well within the limits of play allowed by the mechanism. Finally, it walked up the lane to the works in the softest ground, where there were ruts 8 and 10 inches deep, with the greatest ease.

"On another occasion, in a trial at London, owing to the unskillful handling of the man at the wheel, the engine got into a position in which I thought it must inevitably overturn in the soft bank into which it had fallen; and while I was discussing how it should be got out, the application of steam by the driver caused it to walk out of its difficulties in a way which I can only describe as like that of a cat.

"The action of the pedrail on the road is very remarkable. Whereas the ordinary traction engines destroy roads to such an extent that they have been forbidden in many parts of the world, and heavy motor wagons and traction engines have been severely taxed by local authorities and made to contribute to the repair of the roads, the pedrail positively

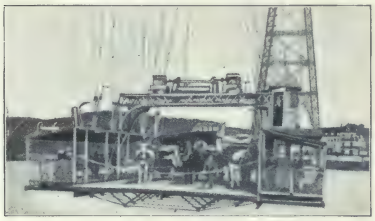


SUSPENSION FERRY OVER THE LOIRE AT ROUEN.

improves the road over which it walks. This has been proved by actual experiment, and it is more than probable, from the remarks of an eminent municipal engineer, that the pedrail is destined to replace entirely the road roller for repairing roads, as the action of stamping or ramming is much better than rolling for this purpose."

SUSPENSION FERRY OVER THE LOIRE

THE most important enterprise to be inaugurated in the French city of Nantes during the present year, is the *pont transbordeur,* or overhead ferry, which will connect the old quays on the north side of the Loire with the new ones on the south side, where the State railway is about to build a large freight depot. The ferry structure is stately and graceful, consisting of two tall steel towers, one on each bank of the river, joined together by a horizontal bridge or railway track 490 feet long and 165 feet above the surface of the

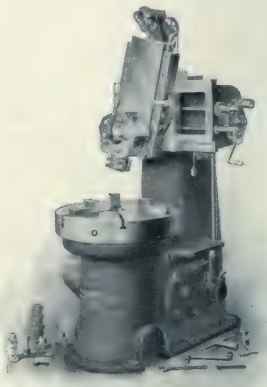


SUSPENSION FERRY CAR IN SERVICE

water. An inverted steel carriage or car travels along the rails; and suspended from this by steel cables, is the platform or ferry, which has two divisions—one for horses, vehicles, and railway cars, and the other for foot passengers. Electric motive power operates the car from which the ferry is suspended, and the crossing is thus quickly and easily effected. Trial trips have already been made, and the ferry is to be thrown open to the public about November 1. The rates are as follows:

	Cents.
Foot passengers	1
One-horse vehicles:	
Empty	5
Loaded	8
Two-horse vehicles:	
Unloaded	7
Loaded	10

This *pont transbordeur* seems to solve the question of crossing rivers or other channels in the simplest and most practical way. It moves rapidly and in no manner interferes with navigation, since, owing to the great height of the bridge from which the ferry is suspended, ships of the tallest masts may pass under it moreover, it does not involve the ascents and descents of the ordinary bridge approaches, and being built on an air line it realizes the minimum distance to be crossed. The cost of this structure was a little more than $200,000, and the projectors believe it will be a paying venture. There is a similar ferry at Bilbao, Spain; and others at Rouen and Martrou, France, and at Bizerte, the French naval station on the coast of Tunis.



VERTICAL BORING MILL

A VERTICAL BORING MILL

THE accompanying illustrations are of the 34-inch vertical boring and turning mill built by the Colburn Machine Tool Company, Franklin, Pa. This machine has the appearance of being a well-built tool suitable for a large variety of work found in all machine shops, and especially adapted for use when a number of duplicate parts are to be turned out. It has

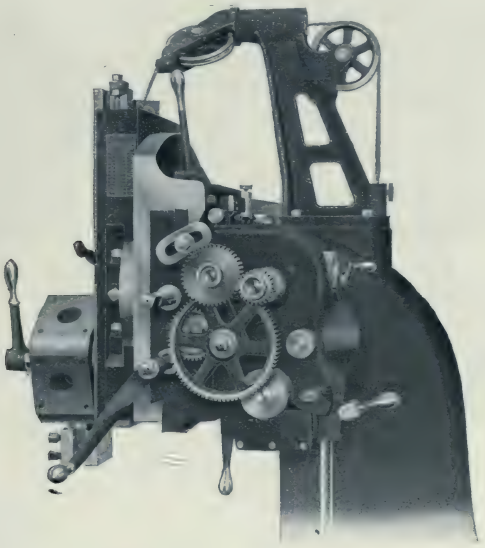
a number of especially attractive features.

The chuck, as will be seen, is of heavy design. The cuts show the 3-jaw chuck, although the builders furnish a 4-jaw chuck or plain table, as the user may elect.

The spindle on which the chuck is mounted is 6 inches in diameter, and runs on a bronze shoulder-ring having angular bearing. The driving-cone shaft is

The feeds are gear-driven, and the power is transmitted to the feed-case mechanism through the vertical feed-shaft. Both vertical and horizontal feeds are provided with adjustable automatic stops.

There are eight available changes of feed for each speed of table. The entire feed mechanism may be stopped, started, or reversed by means of the hand wheel at base of machine. It is also possible to



VERTICAL BORING AND TURNING MILL

placed parallel with the cross-rail; and the machine may be located on the crane floor of the shop and belted up to the countershaft running lengthwise, thus giving a clear space overhead for serving the machine with either a traveling or jib crane.

The table gear is of cast iron, and is made fast to the chuck so that there is no twisting strain on the spindle. It is driven by a 3-pitch steel pinion through a powerful train of gears. The ratio of constant strain is 7½ to 1, and the ratio of back gears is 45 to 1. There are 16 changes of speed, graded to give a perfect geometrical progression.

stop the feed at five different points—namely, by using the rip lever, by withdrawing the trip pinion on feed screw or feed shaft, by dropping out the feed change lever, by placing the multiplying lever in central position, or by placing the feed reverse lever in central position.

There is a generous range of feeds, which are from .012 to .125 of an inch for vertical and angular work, and from .025 to .250 of an inch for horizontal work.

The vertical slide has a travel of 18 inches, either by hand or power, and is carried on a swivel saddle attached to the cross-slide by a central stud. The saddle

is clamped to the cross-slide by four bolts working in a circular T slot. When the power feed is used, an adjustable automatic stop regulates the length of travel, as desired.

We note a very valuable feature in the 18-inch graduated scale, which is attached to the turret-slide cap parallel with the turret-slide. On the slide is an adjustable pointer which moves over the scale, indicating at all times the exact travel of the turret-slide. This is especially desirable for duplicate work.

The counterbalance weight is suspended within the column and connected with the turret-slide. This method of carrying the counterweight eliminates entirely the necessity for overhanging arms to carry the counterweight chain, which is usually employed on mills of this type. The turret-slide can be swiveled to any angle up to 30 degrees either side of the perpendicular. The cross-rail has a travel of 15 1-2 inches either by hand or by power; is equipped with adjustable automatic stops for tripping feed; and also has a lever for clamping slide to cross-rail, doing away with the necessity of using a wrench for this purpose. The turret is five-sided, and the holes are bored to fit tool-shanks 2¼ inches in diameter.

The turret lock-bolt is of hardened tool steel ground perfectly true, and works in a hardened tool steel index-ring also accurately ground. A micrometer dial is set over the collar on the cross-feed screw, which proves a great convenience in providing a fine adjustment for depth of cut.

The thread-cutting attachment can be quickly applied, and may remain permanently attached to the machine without interfering with its regular operation. This is shown in the smaller illustration.

SCHERZER ROLLING-LIFT BRIDGE

THE bridges of this type recently completed at State, Randolph, Canal, and Main Streets, Chicago, Ill.—where they replaced swing bridges—have been so satisfactory that three additional rolling-lift bridges made by the same company have been ordered by the Sanitary District of Chicago, to supersede the swing bridges located at Dearborn, Harrison, and Twenty-second streets. The plans for these new bridges are nearing completion, and bids for construction will be called for within several months; also bids for the construction of a Scherzer bridge at Polk street, for which the plans are now finished.. The work of construction is progressing rapidly on the lift-bridges at Eighteenth street and at Loomis street.

All of these bridges will give clear channels for navigation 140 feet wide, which will enable the largest lake vessels expeditiously to reach the piers and dock anywhere at the numerous railroad terminals, warehouses, elevators, and manufactories located along the Chicago river and its navigable branches. The rapid, direct, and economical interchange of large cargoes made possible by these improvements, will enable Chicago to maintain her advanced position as a manufacturing and transportation center.

The work of removing artificial obstructions to navigation by substituting bascule bridges for swing bridges is also progressing rapidly at many other railroad centers, notably Cleveland, Ohio, where three rolling-lift bridges have already been completed to take the place of swing bridges. A fourth is now under construction for the Newburgh & South Shore Railway Company across the Cuyahoga river. This will be a long-span, double-track, single-leaf bridge, designed for the heaviest railroad loadings.

A large highway bridge of the Scherzer type is nearing completion at South Michigan street, Buffalo, N. Y., where it supplants a swing bridge. The first of the two double-track rolling-lift bridges being built across Newark Bay for the Central Railroad Company of New Jersey, is nearly finished, and will be placed in service within a few months. The substructure of the long-span lift bridge at the mouth of Newton creek, Brooklyn, is nearly completed; and the erection of the steel superstructure will soon be commenced. At Bridgeport, Connecticut, the four-track lift bridge for the New York, New Haven & Hartford Railroad Company will be ready for use within a few weeks. The contract has been awarded for the construction of the rolling-lift bridge at Saginaw, Michigan, and the work of building has commenced.

All the above, and other Scherzer roll-

ROLLING-LIFT BRIDGE OVER CHICAGO RIVER, OPERATED BY ELECTRICITY

ing-lift bridges, replace swing bridges, many of which have been in service for only a few years, but which were found to be so obstructive to navigation and so inadequate to the requirements of the railroad, street, and highway traffic, that it was necessary to replace them with more modern structures. The new plans under way for the removal of swing bridges and the erection of the lift bridges, call for a large tonnage of structural steel, counter weight, and machinery.

The Demand for Engineers

The Possibilities Open to the Technically Trained Man Here and Abroad

THE plan for a great British technical school to cost $1,500,000, submitted by the Earl of Rosebery to the London County Council, will attract wide public attention because of its bearing upon the impending struggle for industrial supremacy between England, Germany, and the United States. In submitting a proposal whereby the County Council is to contribute $150,000 annually toward the maintenance of the school, Lord Rosebery says:

"It is little short of scandalous that our ambitious youths should be obliged to resort to the United States and Germany for technical training."

The controversy over the comparative value of the technical and classical schools in preparing young men for the vocation of life is an old one in England. Englishmen have pointed wtih alarm to the rapid development of Germany's great technical and engineering schools, and have clamored for more liberal appropriations and endowments for institutions of this class. The argument has been made that if England is to maintain her position among the nations that have

made rapid advance in the applied sciences, she must provide greater facilities in the way of scientific and technical training for her young men.

But the menace no longer comes from the engineering schools of Germany alone. Our marvelous strides in manufacturing, in electrical engineering, in mining, and in great steel-construction work, have created a great demand for men of technical training, which, in turn, has caused a rapid multiplication of technical schools in the United States within the past decade. Interviews printed in *The Record-Herald* reveal an unprecedented demand for technically trained engineers. Heads of railroads and great manufacturing institutions in Chicago state that the demand for engineers, designers, and draftsmen far exceeds the supply; while the representative of one firm declares that manufacturers having contracts in foreign countries are obliged to employ foreign engineers to do their work for them.

Of course there is danger that young men, under the stimulus of this temporary demand, may rush into the engineering and technical callings, imperfectly or inadequately prepared, under the impression that large salaries are awaiting them. As a matter of fact, the best the technical school can do is to supply the fundamentals. Ultimate proficiency and high salaries are a matter of practice and of personal adaptability to some special line of work.

Cuban Reciprocity Elucidated

WHEN the fight against Cuban reciprocity was at its bitterest point in Congress, Senator Burrows, of Michigan, received this letter from a perplexed but earnest constituent:

"Dear Senator: If this here receprosty bisnes is fixed between us and Cuba as they say we'll have to grow our own tobac or else make them Cubans rich enough to buy the hull country. I do a littel chawin' myself and I don't b'lieve in buildin' up no trust. I'd like to raise my own plug. I ain't no hand to ask favors, but if you could sent me a package of terbac seed it would be remembered.

"P. S.—I want to raise the kind of plug with tin things onto it."

Duty Sometimes Comes Hard

FRANK A. VANDERLIP, now one of the vice-presidents of the National City Bank of New York, the great Rockefeller stronghold, was financial editor of the *Chicago Tribune* in 1892 and 1893—a hardworking newspaper man, dependent on his salary.

Those were panic times. Banks were failing every day. Joseph Medill, the editor of the *Tribune,* was in Southern California. He was much exercised over the situation and was in close touch with the office, constantly advising conservatism and optimism in the newspaper reports.

Vanderlip, by close economy and some minor investments, had saved $800. It was all he had. One day the bank failed in which he had deposited his little nest egg. He went despondently to his desk. The world looked black to him. It was a hard blow.

A messenger boy came in with a telegram. Vanderlip signed for it mechanically—his thoughts were on his lost $800. He tore open the envelope. The telegram was from Mr. Medill. It read: "Take a cheerful view of the situation."

The Sea Wall at Galveston, Texas

A Description of the Great Engineering Work which, in Conjunction with the Projected Raising of the Level of the City, will Afford Absolute Protection against the Recurrence of Disastrous Floods from the Gulf

By J. H. JOHNSTON
Secretary Galveston Chamber of Commerce

THE story of the great hurricane and overflow at Galveston, Tex., in September, 1900, together with its harrowing tales of loss of life and destruction to property, are familiar to the reading public of this country; but it is not so well known that that once stricken city is again on the high road to fame and fortune, and that the tide of commerce once more flows uninterruptedly through its magnificent harbor and over the restored and enlarged wharves. Indeed, the total trade of Galveston in 1902 was greater than ever before in the history of this great southern port.

Of course, the natural advantages of the harbor, together with its strategical location as the gateway to the great agricultural states of the southwest—it being the only port of prominence west of New Orleans on the Gulf coast, and much nearer to the producing territory than that city—have been conducive to the rebuilding of Galveston, as they were the cause of its original growth; but perhaps the one thing that has had the most to do with the restoration of confidence is the planning and erection of a great sea wall, which is confidently expected to protect the city thoroughly from danger of any overflow similar to that of 1900.

PHOTOS BY H. H. MORRIS, GALVESTON, TEXAS.

SEA WALL UNDER CONSTRUCTION, SHOWING MOULDS

This magnificent structure, while a work of too great magnitude to be yet completed, is well under way, and a large section is now ready to withstand any blows which King Neptune may aim against it.

The plans of protection, as outlined by

a board of eminent engineers selected for the purpose, include—besides the construction of the concrete sea wall proper—the filling or raising of the grade of the city to a level with the top of the wall. In this way it will be necessary, if the wall is to be destroyed and the water to reach the city, to wash away the entire island, thirty miles long and three miles wide—a practical impossibility.

A PORTION OF THE COMPLETED SEA WALL

The different features of the great undertaking, in addition to being engineering feats of note, are of considerable interest to the average spectator; and large crowds of visitors are daily attracted to the scene of operations.

The first steps in the process of construction consist in the preparation of a suitable foundation to bear the great weight of the wall proper; then the provision of additional safeguards to the structure, to prevent undermining, keep off the full force of the water, etc. The erection of the wall itself is the last step.

First is the driving of long 40-foot piles into the earth until their heads are barely covered with soil, while their bases rest upon a stratum of clay underlying Galveston Island at about that depth. In front of these piles, which are in rows parallel with the course of the wall and at intervals of about three feet in each row, is driven another row of what is called "sheet piling," or heavy timbers in a close row forming a sort of underground board fence, designed to prevent the waves from washing out the earth between the piles proper and undermining the wall. All of these piles are driven by immense cranes and steam-hammers combined, which grasp the pile from a stack on the ground, lift it into an upright position, and then proceed by heavy blows to hammer it into the ground, aided by a powerful jet of water, which softens the earth and assists its downward progress. The process is quite well illustrated in the accompanying pictures.

As an additional protection against undermining, and to prevent the full force of the waves from dashing against the wall, there is placed in front of the piling foundation, right on the surface of the earth (though it afterwards partially sinks into the ground by its own weight), a row 27 feet wide of large, irregular pieces of granite, called "riprap." This is in itself a formidable barrier to the waves, regardless of the wall proper, though its only intent is as an accessory safeguard to the main structure.

The completion of the foundation is the next step. The heads of the piles are uncovered to the depth of a few feet, and over and around them is placed a mass of concrete, which, when allowed to harden, forms what has the appearance of a solid granite walk 16 feet wide and 3 or 4 feet thick, extending the full length of the wall. This concrete is the same material of which the wall itself is made, and is prepared by mixing in a large mixer, or sort of churn, operated by machinery, a mass of the best Port-

land cement, crushed granite, and water, which, as intimated above, when spread out and allowed to dry, forms a mass as hard as solid rock. It is of this same substance that the Government fortifications at Galveston are constructed; and it would seem that it would take a very great force of water to demolish a structure made of material suitable to withstand the shock of 13-inch projectiles hurled from modern ordnance. Indeed, some of the concrete forts were exposed to the full fury of the 1900 storm, being right on the beach; and while they were somewhat injured, the damage was almost entirely caused by undermining, the Government not having taken the precaution of placing either riprap or sheet-piling protection for their foundations.

Last but not least is the erection of the wall itself. This is done in sections of

PLACING RIPRAP

50 feet, each of the regulation height and width. Large wooden caissons or frames are built, and into these are dumped the wet concrete, after which the mass is tamped down and left for a short time to dry, when the frame is removed and the completed section stands forth in all its glory and pride of new-born strength.

The height of the wall is 17 feet above the sea-level, or about a foot higher than the highest water of the fearful flood of 1900. The wall is 16 feet thick at the base and 5 feet thick at the top, the outer surface gradually sloping upward and inward so as not to present too bold and sharp a front to the waves. The total length of the sea wall will be 17,593 feet, or about 3½ miles; of this about 3,600 feet has been completed, though of the preliminary steps a great deal more has at this writing been accomplished, over half of the piling foundation having already been driven.

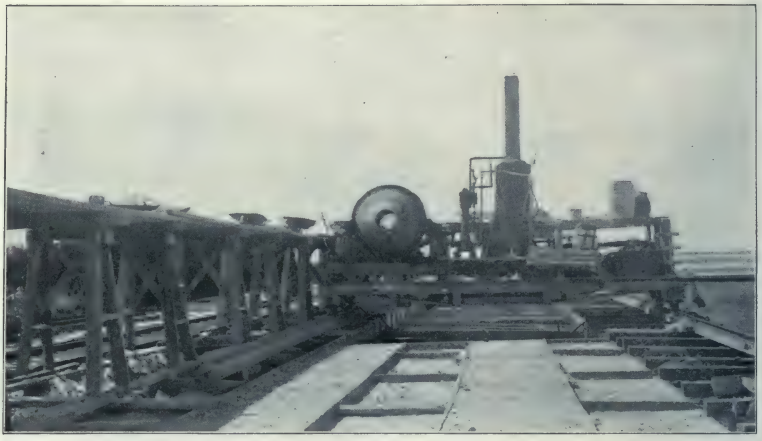
As mentioned before, when a little further progress shall have been made with the wall, the raising of the grade of the city will be taken hold of and prosecuted vigorously. Already a board or commission to take charge of the work has been appointed by the Governor of Texas; and while the board has not yet definitely decided the plans by which the work will be carried out—whether by dredging from the Gulf, or by hauling soil from the mainland or further west on the

COMPLETE SECTION, SIDE AND BACK VIEW

Island—a supervising engineer has already been selected in the person of Captain C. S. Riche, of the United States Engineer Corps, one of the foremost men of his profession.

The raising of funds to insure the success of the entire undertaking is no longer a matter of speculation—they are assured. For the sea wall proper, which will cost $1,500,000, bonds have been issued by the county government; and of these about a million has been taken by citizens of Galveston, the remainder by outsiders. This is a great showing for a community so stricken as was Galveston.

The raising of the grade, it is estimated, will cost $2,000,000; and to obtain this amount the State of Texas has, by special act of the Legislature, granted to Galveston county all of its state taxes for a period of seventeen years, to be used for this purpose alone. It is expected that fully $1,250,000 will be forthcoming in this way, so that only $750,000 will be left to be raised in order to complete the work.



MIXERS AT WORK ON FOUNDATION

All things considered, Galveston's future is at present quite rosy—with these great projects assuring absolute protection from danger of overflows, with new railroads and steamship lines headed this way. All these things indicate a great future for the once storm-stricken city.

The Industrial Conscience

A Few Pertinent Remarks on Certain Tendencies that bear on the Relations of Capital and Labor

A CONDITION which is causing more mischief between employer and employed than anything we can imagine, is brought to public attention in a very direct manner by a recent editorial in the Boston (Mass.) *Evening News*. The lesson is not confined to any particular trade or profession; it is one that we may all take home to ourselves. Every man and woman, no matter how or where he or she may be employed, is morally accountable to give 100 cents worth of labor for 100 cents worth of pay.

"From our point of vantage, ten stories above the street," writes the Editor, "we have been watching three or four men, whose wages presumably are paid by the taxpayers of the city, clean and repair the gutters on the roof of the City Hall. It was the claim of a certain manufacturing concern, on retiring from business, that it could not count on more than a third of a day's labor from the general run of its workmen. Figuring on the ease with which these City Hall fellows go about their tasks, we are inclined to think that Boston can shake hands with the firm that has given up business. It isn't so much that the men are actually idle as that they don't work as if their hearts were in their work.

"How deeply into the ranks of labor has this degeneracy of the industrial conscience penetrated? Incidental observation, and the experience in employing others that comes to the average man, indicate that it has gone far enough to

make it quite essential that it shall go no farther. We are keenly alive to the faults and meannesses of many men who employ labor. We condemn them heartily. We are disgusted when a man rich and influential whines about the burden of his wealth. It is all cant and hypocrisy. But there are two sides to every controversy, and usually the two sides prove to be something more than the right side and the wrong side. To deal justly with all parties, the rights of all parties must be recognized. Labor is naturally keen to promote the rights of labor; but does labor always take into account that one of the rights of labor is honestly to earn its pay; or if it does take that into account, does it always act as if it did? We are not so foolish as to declare that if employees always worked heartily and devotedly for their employers' interest they would always find such honest efforts justly rewarded by all employers. We know they wouldn't, for many employers are exactly as mean as the meanest men who work for them, and meaner, too, for they are in the more responsible positions. But we do say that the average employer is more likely to reward conscientious, unselfish endeavor than he is to increase the wages of laxity and general perverseness. More, even, than that, is the deeper truth that conscientious and unselfish endeavor never fails to reward by increased manliness, fuller self-respect, and more solid character development every one who practices it.

"The industrial conscience, as a whole, is composed of the consciences of both individual employers and employees. It avails nothing to the employer who is not treating his men right, to declare that he would do right if his men did right. He must get himself right before he can prove his right to employ men who are right. On the other hand, it is equally beside the mark for employees to excuse their delinquencies by the plea that if their bosses used them square they would be square. Nor is the claim that they earn all that they get a conclusive argument in favor of more than they get. Fundamentally, every man is working for himself, and for himself alone. When an employer cheats his employee he is cheating the community at large; and inasmuch as every man's interests are inseparably linked with the community's interests, such an employer is actually cheating himself. When an employee cheats his employer by not working to the best of his ability, he, too, is cheating himself, for no man can cultivate carelessness without in the end reaping carelessness. After all, the problem of labor and capital is simply the problem of doing right, regardless of personality. Some day we all of us must put ourselves and our work on that basis. The first step toward doing it is for each one of us to begin."

Joints in Carpentry

Various Methods of Joining Timbers in House Construction

By GILBERT TOWNSEND, S. B.

Structural Engineer, with Post & McCord, New York City.

THE number of methods employed in joining pieces of timber together is really very small, and the principles upon which they are based may be mastered very quickly.

All connections between pieces of timber may be classified as joints or as splices. By a "splice" we mean a connection between two pieces which extend in the same direction, and each one of

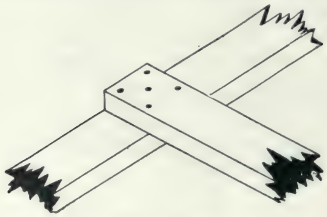


FIG. 1. JOINT.

which is merely a continuation of the other. The only reason for the existence of such a connection is the fact that sticks of timber are limited in length, and must therefore be pieced out. By a "joint" we mean any connection between two pieces which come together at an angle, as shown in Fig. 1, and which are therefore not continuous. Such a connection may be required in a great many places, and especially at the corners of a building.

The principal kinds of joints to be met with in carpentry are the "butt joint," the "mortise-and-tenon joint," the "gained joint," the "halved joint," the "tenon-and-tusk joint," and the "double tenon joint."

The Butt Joint

This is the most simple of all the joints, and is made by merely placing the two pieces together and nailing them firmly

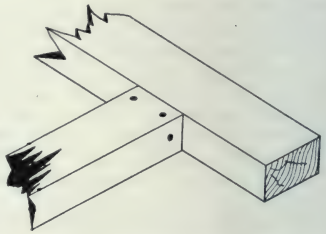


FIG. 2. BUTT JOINT.

to each other after both have been trimmed square and true. Such a joint is

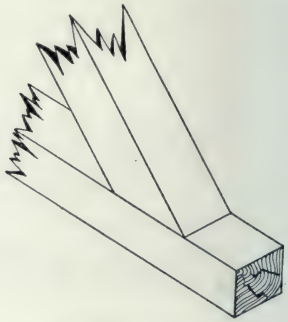
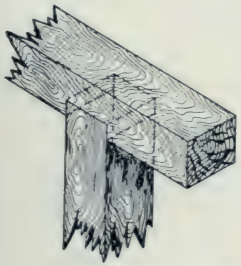


FIG. 3. OBLIQUE JOINT.

shown in Fig. 2. The two pieces are perpendicular to each other and neither piece is cut. The nails are driven diag-

onally through both pieces, an operation which is known as "toe-nailing," and are driven home, if necessary, with a nail set. This is called a "square" butt joint. Fig.



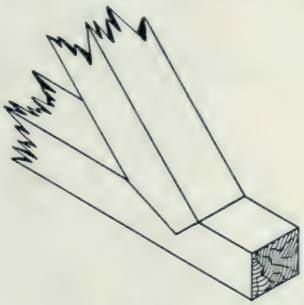


FIG. 4 A. MODIFIED BUTT JOINTS. FIG. 4 B.

3 shows two pieces which are not perpendicular to each other. They are trimmed to fit closely together, and are then nailed in place. Such a joint is called an "oblique" butt joint. The butt joint does not make a strong connection between the pieces, and should not be used if much strength is required. It depends entirely upon the nails for its strength, and these are very likely to pull out.

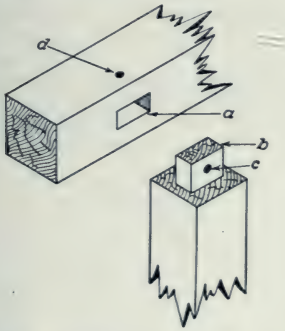


FIG. 5. MORTISE-AND-TENON JOINT.

This form of joint is sometimes modified by cutting away a part of one of the pieces, so that the other may set down into it as shown in Fig. 4, the square joint at A, and the oblique joint at B. This adds much to the strength of the joint, especially in the construction shown at B, where there may be a tendency for one piece to slide along the other.

The Mortise-and-Tenon Joint

From the modified butt joint it is but a step to the "mortise-and-tenon" joint, which is formed by cutting a hole, called a "mortise," in one of the pieces of timber, to receive a projection called a "tenon," which is cut on the end of the other piece. This is shown in Fig. 5. The mortise is at *a* and the tenon at *b*. It will be noticed that there is a hole bored through the tenon at *c*, and another hole in the mortised piece at *d*. These holes are so placed that when the pieces

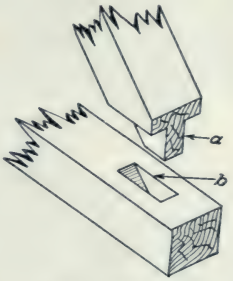


FIG. 6. BRIDGE JOINT.

are joined together, a wooden pin may be driven through both holes, thus preventing the tenon from being withdrawn from the mortise. This pin should *always* be inserted in a mortise-and-tenon joint. Ordinarily it is of hard wood even when the pieces to be joined are themselves of soft wood, and it may be of any desired size. Round pins from three-quarters to

seven-eighths of an inch in diameter are ordinarily used, although it is sometimes better to use a square pin.

The Bridge Joint

The form of mortise-and-tenon joint described above may be used wherever the pieces are perpendicular to each other. When, however, the pieces are inclined to

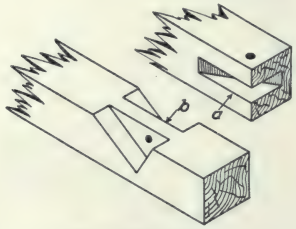


Fig. 7. Bridge Joint.

each other, a modification of the above joint known as the "bridge" or "straddle" joint is employed. This joint is shown in Figs. 6 and 7. It is similar to the square mortise-and-tenon joint, having a similar mortise and tenon, but these are cut in a slightly different way. In Fig. 6 the tenon *a* is cut in the end of the inclined piece, and fits into the mortise *b* cut in the other piece. In Fig. 7 the mortise *a* is cut in the end of the inclined piece and the tenon *b* is cut in the other piece.

The Gained Joint

The joints which have thus far been described are applicable only where the bending and shearing are to be expected, as in the case of floor beams connected to sills or girders, a slightly different sort of joint must be used.

One of the most common joints for such places is a modification of the mortise-and-tenon joint which is known as the "gained joint." An example of this form of connection is shown in Fig. 8, and it may be seen that the end of one piece is tenoned in a peculiar way. The tenon proper is the part *a-b-c*, and this tenon sets into a corresponding mortise cut in the other piece as shown. It is evident that the tenon cannot be held in place by a pin, but it may be secured by nailing.

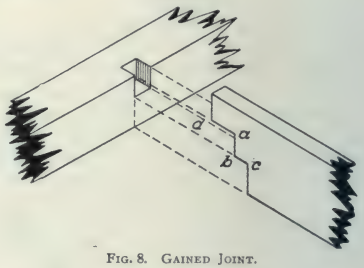


Fig. 8. Gained Joint.

The reason for this peculiar form of tenon may be explained as follows: A floor beam, or any other timber which is loaded transversely, has a tendency to fall to the ground, and must be supported at its ends either by resting directly on a wall or sill, or by being mortised into the

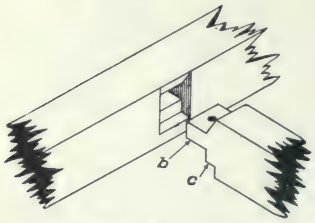
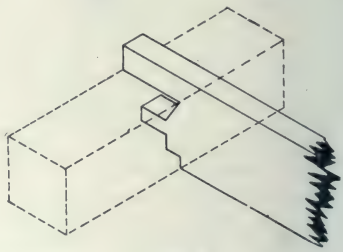


Fig. 9.



Tenon-and-Tusk Joints. Fig. 10.

members are subjected to direct compression, as in the case of posts or braces, or in certain cases where direct tension is the only force acting on the pieces. When

latter member. Moreover, in order that the end of the piece resting on the support may not be crushed or broken, a certain amount of bearing surface must be

available. This same bearing surface must be provided in every case, no matter whether the timber rests directly on the top of the sill or is mortised into it.

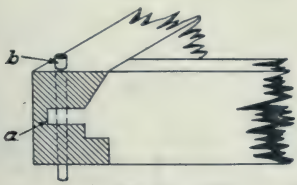


FIG. 11. METHODS OF SECURING TENONS.

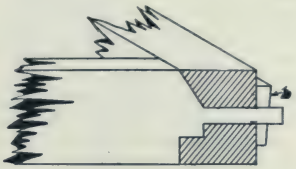


FIG. 12.

Of course the simplest connection is obtained by resting the transverse piece directly on top of the sill without cutting either piece; but such a joint is not stiff and strong, and it is often necessary to bring the timbers flush with each other at the top or at the bottom. For this reason a mortised joint is used; and in order to obtain the required amount of bearing surface without too much cutting, the tenon is formed as shown. The available bearing area is furnished by the surfaces *d-a* and *b-c*, and it may easily be seen that this area is the same as would be available if the piece rested directly on top of the sill. The operation of cutting such a tenon and mortise is known as "gaining," and one piece is said to be "gained" into the other.

The Tenon-and-Tusk Joint

A joint in common use in such situations as have just been mentioned, is a development of the gained joint which is called the "tenon-and-tusk" or the "tusk-tenon" joint. This joint is shown in Fig. 9. The characteristic feature is to be found in the peculiar shape of the tenon which is cut in the end of one of the pieces to be joined, as shown in the figure. It may be seen that there is a small square tenon *b* cut in the extreme end of the piece, and that in addition to this there are other cuts *c* which constitute the "tusk." The bearing area is furnished partly by the under side of the tenon and partly by the under side of the tusk.

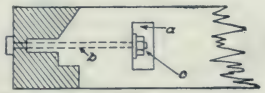


FIG. 13. METHOD OF SECURING TENON.

This joint makes a very good connection, and the cutting of the mortise does not weaken the piece of timber so much as does the mortise for a gained joint. It is especially applicable when it is desired to have the pieces flush on top, though it may also be used in other positions. When the top of the tenoned piece must project above the top of the mortised piece, the tenon may be cut as shown in Fig. 10.

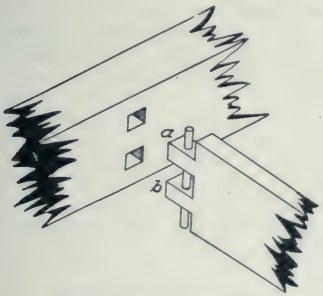


FIG. 14. DOUBLE TENON JOINT.

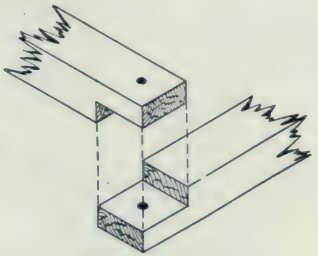


FIG. 15. HALVED JOINT.

There are several ways of securing the tenon in place. The simplest is that shown in Fig. 11, where the pin *b* is passed through the tenon and the mortised piece so as to hold the tenon securely in place. Another scheme is to cut the square tenon a little longer, as shown in Fig. 12, so as to pass clear through the mortised piece, and to fasten it with a peg *b* on the other side. The peg may be cut slightly tapering, as shown, so that when it is driven in place it will draw the pieces together. Still another plan is shown in Fig. 13. Here a small, square hole *a* is cut in the header some distance back from the

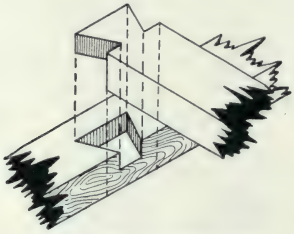


FIG. 16. DOVETAIL HALVED JOINT.

tenon, and a nut *c* is placed in it, while a bolt *b* is passed through a hole bored lengthwise in the header to receive it. The bolt passes through the nut, which may be screwed up tight, thus drawing the pieces closely together and making the joint tight. In screwing this up, the bolt is turned, while the nut is held stationary by the side of the square hole in which it is inserted and which is just large enough to receive it.

The Double Tenon Joint

Fig. 14 shows a form of tenon joint called the "double tenon" joint, which is not very extensively used at the present but which has some advantages. As may be readily seen, there are two small tenons *a* and *b* through which a pin may be passed if desired.

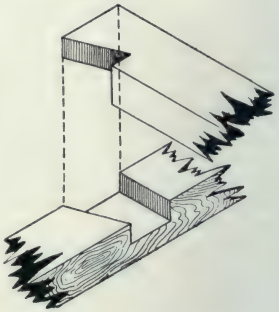


FIG. 17. DOVETAIL JOINT.

The Halved Joint

A form of joint which may be used to connect two pieces that meet at a corner of a building, is shown in Fig. 15. This is known as the "halved" joint from the fact that both pieces are cut half-way through and then placed together. The pieces are held in place by nails or spikes. If one piece meets the other near the center instead of at the end of the piece, and if there is danger that the two pieces may pull away from each other, a form of joint called the "dovetail" halved joint is used. This is shown in Fig. 16. Both the tenon and the mortise are cut in the shape of a fan, or dovetail, which prevents them from being pulled apart. This joint may also be cut as shown in Fig. 17, with the flare on only one side of the tenon, the other side being straight.

Good Citizenship

An Exposition of a Young Man's Duty as a Member of the Community—His Privileges, Burdens, and Prospective Rewards—With Pertinent Hints as to the Requisites for a Broad-Minded Solution of the Great Present-Day Problem of Harmonizing the Interests of the Capitalist and the Workingman

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Address Delivered before the Students of Armour Institute of Technology

By Hon. ELIHU ROOT, Ex-Secretary of War

* * * Being a politician does not mean merely going to primaries and interesting one's self in the machinery of politics; it means having mind and heart centered upon the harmony and welfare of the country, the promotion of every high ideal in politics, the promotion of honesty and honor in public life, adherence to the men who recognize those ideals, and condemnation of the men who do not—taking a *practical* part in the great social movements, and also in the small movements, in the community.

A dear friend of mine—one of the dearest whom I have ever had and who has just passed away—Senator Hanna, was one of the most successful politicians of his day; but the thing that distinguished Senator Hanna's life more than anything else in its closing days, was the extreme loyalty and solicitous interest that he was taking in the Civic Federation, which he was attempting to make the means of uniting all reasonable men in the ranks of capital and in the ranks of labor. His belief in the Civic Federation, his sympathy with the laborer as well as with the employer, and his knowledge of their feelings, his efforts to bring about a perfect conciliation on the ground of common interest and common patriotism, were characteristics of the politician in the highest sense.

Your presence here in this Institute is a warrant that you are looking forward to a life of work; that you are going to work; and each one of you looks to his own course in life. You will be brought into immediate contact with the man who works, on the one side, with the brains that invent, and discover, and organize, and employ labor; and, on the other hand, with the men who execute and produce. The perpetuity of the institutions to which you are indebted for your opportunities in life depends upon those who are not at war, not enemies, not one on one side and the other on the other, glaring at each other as savage foes, but who are upon the middle ground of reason, united by the thought of capital being made reasonable and fair in its dealings with labor, and labor being made reasonable and fair in its dealings with capital, so that there shall be a public sentiment which will constrain the unduly grasping and selfish and overreaching men who are trying to get with their capital all there is, and which will constrain the violent, aggressive, and inconsiderate laboring men who are trying to burst the bands of capital and sweep away the capitalist.

It rests with you and the other young men of America like you, who are going out into the world to work for themselves, to work for their country, for their

homes, for the generations that come after them, to make one ideal stand for the capitalist and for the laborer—the ideal of *fairness* in the country's institutions.

There is unison up to a certain point; up to the point where buying is done, there is absolute unanimity; but the capitalist cannot make a profit upon his money until orders are received for the things he manufactures and the things he manufactures can be sold at a profit. The workman cannot make his home and educate his children until the orders are received. Thus far they stand together. When we go beyond that, if both sides are fair, then there is reciprocity of interests. If either side is unduly grasping and unfair, then strife begins.

The way to settle this great labor question, which underlies all questions, is not by denouncing capital as if it were represented solely by the grasping and unfair, not by denouncing labor as if the agitators were its sole representatives, but by getting together the reasonable men of both sides—men who are willing to be fair—and helping them to control and lead the men of both sides; getting the reasonable and fair laboring man to exercise his influence over all laboring men, and the reasonable and fair capitalist to influence all capitalists. And that can be done, for we are a reasonable people. Reason does dominate us, and an appeal to the common sense of America is sure to receive a satisfactory response. Now, that is the only way in which we can perpetuate the institutions that have given us all we have. For this is a government of the people, and by the people,

HON. ELIHU ROOT
EX-SECRETARY OF WAR

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where the votes that are cast on election day determine how we shall be governed and whether prosperity shall reign.

There is no possibility of the continuance of the institutions of the government of our free republic, unless it rests upon the confidence of the men who cast the votes. The great body of men who cast the votes must believe that the government of America is just and fair; they must believe that a man, however poor, however humble he may be, has a *fair chance* in America. They must believe that it is not necessary to take arms in their hands and have recourse to revolution, as in the states of Central and South America—that it is not necessary to do that, because an appeal to the people will always secure a citizen's rights. The men, I say, who cast the votes (and the great bulk of them are those who work with their hands) must believe that in America justice is done. This can be attained only by having our government fair to all citizens; by being fair one towards another; by having something higher to live for than making one dollar to-day and two dollars to-morrow; by having a guide in our consciousness of duty so that each one shall do his share towards securing an honest, orderly government. And if each one will do that—doing his duty by his country, being loyal to the memory of the men who have given us the greatest opportunity that the world ever gave to man, being true to our own higher duty—then America will go on raising higher the standard of mankind.

Let me say one word more to you. Remember—"he that seeketh shall lose." No man ever gained the highest prize by seeking. The man who does his duty, inspired by an unselfish desire to accomplish some good and noble end, finds that all things come to him; while the man who selfishly concentrates his efforts upon the things he wants for himself, finds them turn to ashes as he grasps them. Do your duty by your country; take the time and the trouble and the patience to be good, loyal Americans, and you will find that the blessings that the world of freedom and justice has in store will be yours without your seeking, and you will be able in the future to hand down to your children a more glorious heritage than your forefathers handed down to you.

The Making of a Captain of Industry

Being Chapters from the Early Life of John Botts, now President of the International Air Engine Company

III.—THE LESSON OF HONESTY

By HENRY M. HYDE
Editorial Writer on the *Chicago Tribune*

WHEN we were still living on the farm, I went to a little country school at the corner of the cross-roads, and one of the mottoes in our first copy book was the old proverb "Honesty is the Best Policy."

I copied that proverb more than a hundred times, until it was firmly fixed in my memory; and, in common with all the other pupils at the school, I labored under the delusion that I knew just what it meant.

My idea was that if you didn't lie or steal you were honest—which may be a good enough definition for a savage or for a man who is content to stay in some small, obscure position all his life. But for an ambitious young man who aims at some degree of wealth, power, and usefulness in the world, it is necessary to put a much sharper edge on the old saw.

I never really knew what "Honesty is the Best Policy" meant, until after I had gone to college. The lesson was taught me by old Professor Smith, and he did it unconsciously, his real effort being to teach me the truth of the religion he believed in.

It has always seemed strange to me that that unworldly old man, who knew no more about business than a four-year-old child, should have been the means of my learning what is certainly the greatest principle of success in business life. Old Professor Smith is still alive. Last year I endowed the chair which he still fills; and I sent, with my check, a letter in which I told him that, as he had taught me how to get rich, it was only fair that I should share my prosperity with him. The old man showed that he was puzzled when he sat down to acknowledge the endowment. "I can't really think that I had anything to do with it," he wrote. "The idea of me, who have not a dollar to my name, teaching you, or anybody, how to get rich, strikes me as a joke."

But he did teach me the lesson, and this is how he did it:

Ever since I was able to talk, various people had been talking to me about religious matters. Chiefly as a result of my mother's training, I had early become a church member; but there were always a great many things connected with the belief which puzzled me. I talked with all sorts of men about my difficulties, among them certain doctors of divinity; but I never seemed to get my doubts all settled. They were always ready to advance arguments in answer to my inquiries, but, for some reason or other, these arguments were not altogether convincing.

By the time I started for college, I was pretty well unsettled. I wasn't sure of anything. I didn't know what I believed or what I didn't believe. The only good thing about my attitude of mind was my willingness to be convinced. I may say, in passing, that a willingness to be convinced is a great help to a business man. It protects him from the evils of consistency, which, of all jewels, is the pastiest.

I struck college and old Professor Smith the same day—a fact for which I can never be sufficiently grateful. He was an old-looking young man, with a brown whisker under his projecting chin, and his broad shoulders already bent in the scholar's stoop.

"Come around after supper to-night and smoke a pipe with me, Botts," said the professor.

I went, and we sat for two hours under

a big oak tree on the college campus. I sat and smoked, and he sat and talked in answer to my questions. Of course I tackled him on the religious questions which bothered me, and he seemed to make most of them perfectly clear to me, for the first time. I left him in a white glow of enthusiasm, and went home to think it over.

Why had the arguments of Professor Smith convinced me, when practically the same arguments, advanced by other men, had left me still uncertain? I didn't get that point clear the first night; but, in the course of the first term, it gradually grew clear to me. It was because he was honest—that was all.

He had started out by being honest with himself. He had thoroughly and completely convinced himself before he had tried to convince anyone else. There was no uncertainty, no question in his voice or in his manner. He knew what he was talking about. He had thought and studied it all out. Because he was honest he was earnest, and earnestness can accomplish even the impossible.

Because he had settled these great questions in his own mind, and because he knew their vital importance, he was enthusiastic and sympathetic with me. If it was important and satisfying to him to have these questions settled, he knew that it was equally important and would be equally satisfying for me to have them settled. He had passed safely through the same stages of doubt and depression through which I was passing, and he wanted to help me to get through safely.

So, instead of being cold and dictatorial in his talk, he was warm and sympathetic. There was that in his manner and in the very tones of his voice which appealed to me. The reaction in my mind was instant. Instead of being repelled and standing firmly on my guard, I was as anxious to understand and to believe as he was to help me to understand. His voice was so earnest and so honest that it made me earnest, and made it easier for me to believe. The old argument gained new force as I saw absolute sincerity shining in his eyes. Instead of trying to drive me, he led me step by step, always being ready to stop and help me over a hard place. He made me *want* to believe, and then—before I knew it—I *did* believe.

But this is not a sermon. The religious teachings of Professor Smith are mentioned only because he taught me at the same time how to get rich and be successful.

The first application of the lesson is that a business man must know his business thoroughly. He must be honest with himself before he can impress other people with his honesty. How many salesmen have failed because they did not thoroughly believe in the goods they were trying to sell? How can you expect to convince other people that your goods are the best, unless you first yourself believe that they are the best? If there is any doubt or question in your mind, that doubt or questioning is certain to be conveyed to the mind of the man you are talking to.

All men are unconscious mind-readers.

That is the great advantage of study. A thorough knowledge of a business is the first requisite to success in that business.

Given that—and earnestness, enthusiasm, and sympathy will all follow.

Those qualities, properly directed and applied, have been chief factors in making me a successful business man. Honesty is still the best policy in business, but the word "honesty" means much more than might be apparent on the surface to everyone.

Familiar Geometric Figures

An Explanation in Simple Language of the Properties of the Curves of Conic Sections

By ERVIN KENISON, S. B.

THE geometrical figures formed by the intersection of a plane and a cone are called "conic sections." These figures—the circle, the ellipse, the parabola, and the hyperbola—have each their special uses in engineering and architecture.

The Circle

A plane perpendicular to the base and passing through the vertex of a right circular cone forms an isosceles triangle. If the plane is parallel to the base, the intersection of the plane and conical surface will be the circumference of a circle.

The Ellipse

The ellipse is a curve formed by the intersection of a plane and a cone, the

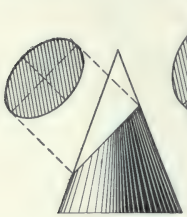


FIG. 1.

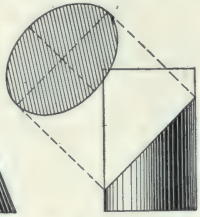


FIG. 2.

plane being oblique to the axis but not cutting the base. If a plane is passed though a cone as shown in Fig. 1, or through a cylinder as shown in Fig. 2, the curve of intersection will be an ellipse. An ellipse may be defined as being *a curve generated by a point moving in a plane, the sum of the distances of the point to two fixed points being always constant.* Thus in Fig. 3, FO+OG = FQ+QG = FR+RG. The two fixed points are called the *foci* (F and G, Fig. 3), and lie on the longest line that can be drawn in the ellipse. One of these points is called a *focus.*

The longest line that can be drawn in an ellipse is called the *major axis;* and the shortest line, passing through the center, is called the *minor axis.* The

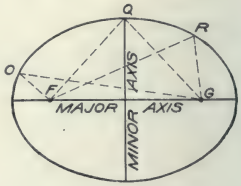


FIG. 3.

minor axis is perpendicular to the middle point of the major axis, and the point of intersection is called the *center.*

An ellipse may be constructed if the major and minor axes are given, or if the foci and one axis are known.

The Parabola

The parabola is a curve formed by the intersection of a cone and a plane parallel to an element, as shown in Fig. 4. The curve is not a closed curve. The branches approach parallelism. A para-

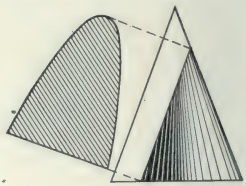


FIG. 4.

bola may be defined as being *a curve every point of which is equally distant from a line and a point.* Thus, in Fig. 5, LA = AF, MB = FB, and NC = FC. The point is called the *focus,* and the given line the *directrix.* The line perpendicular to the directrix and passing

through the focus is the *axis*. The intersection of the axis and the curve is the *vertex*.

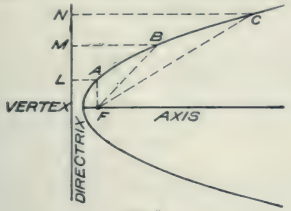


FIG. 5.

The Hyperbola

This curve is formed by the intersection of a plane and a cone, the plane being parallel to the axis of the cone as shown in Fig. 6. Like the parabola, the curve is not a closed curve; the branches constantly diverge. A hyperbola is defined as being *a plane curve such that the difference of the distances from any point*

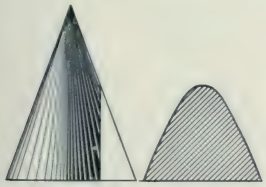


FIG. 6.

in the curve to two fixed points is equal to a given distance. Thus, in Fig. 7, BF—BG = AF—AG. The two fixed points are the *foci*, and the line passing through them is the *transverse axis*.

The Rectangular Hyperbola

The form of hyperbola most used in Mechanical Engineering is called the *rectangular hyperbola* because it is drawn with reference to rectangular coördinates. This curve is constructed as follows: In Fig. 8, OX and OY are the two coördinates drawn at right angles to each other. These lines are also called *axes* or *asymptotes*. Assume A to be a known point on the curve. In drawing this curve for the theoretical indicator card, this point A is the point of cut-off.

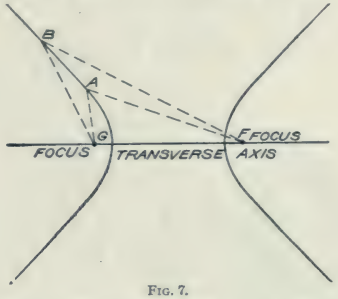


FIG. 7.

Draw AC parallel to OX, and AD perpendicular to OX. Now mark off any convenient points on AC, such as E, F, G, and H; and through these points draw EE′, FF′, GG′, and HH′, perpendicular to OX. Connect E, F, G, H, and C with O. Through the points of intersection of the oblique lines and the vertical line AD, draw the horizontal lines LL′, MM′, NN′, PP′, and QQ′. The first point on the curve is the assumed point A, the second point is R, the intersection of LL′ and EE′. The third is the intersection S of MM′ and FF′; the fourth is the intersection T of NN′ and GG′. The other points are found in the same way. In this curve the products of the coördinates of all points are equal. Thus LR × RE′ = MS × SF′ = NT × TG′.

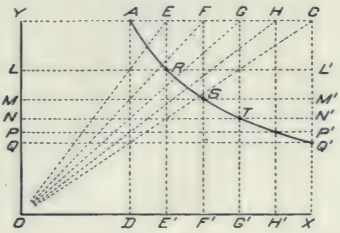


FIG. 8.

Practical Talks by Practical Men

III.—Address Delivered before the Students of Armour Institute of Technology, October 26, 1903

By HERBERT E. STONE
Past President, National Association of Stationary Engineers

H. E. STONE

GENTLEMEN: To be an engineer at the present time is no disgrace to any man; and to be a graduate of a first-class technical school, such as this institution is, means to be a man of very high standard.

I am reminded that about forty years ago, a gentleman offered to the oldest University of our country a sum of money for the purpose of establishing within the curriculum of that University a technical school; and the only recorded example of a University refusing money occurred at that time, when Harvard refused the bequest on the ground that the aim of the institution was to furnish a thorough Classical and English education. From that time to the present, the authorities of the University have carefully exerted themselves in every way to make up for the loss of the original bequest. Having been connected with old Harvard for a long time, and knowing the conditions which exist there, and the efforts being made to further the advancement of the Lawrence Scientific School, I presume that in time it will become such a school as it ought to have been years ago.

It is not so very many years ago that the professions might be numbered on the fingers of one hand; but the engineering classes are now, and have been for some years, numbered among the professions, and considered just as honorable as any. I am aware that this Twentieth Century will demand from the engineer even more than in the past has been demanded from other professions.

In a city twenty-two miles from Boston, I recall a venerable graduate of Harvard Medical School, eighty-four years of age, who, it seemed to me, had within his mind about everything that a man could know in regard to the practice of medicine. Sitting in his study one day, I noticed on the table a number of the latest medical works, and I said, "How does it happen that you are reading these new books? You certainly cannot learn anything from them." He replied, "I knew all there was to be known about medicine in 1847; but these young fellows now know so much that I have to study to keep up with the practice of the times. In the old days, people were satisfied to say they had lung fever; but now, unless they can have Desquamative Pneumonia, they won't be sick." And so the trend of education in the last few decades has led to the profession of the stationary engineer.

Training and education of the most varied sort must enter into the regular work of the engineer, to whatever class he may belong; and if the stationary engineer of to-day does not bend every effort to keep up with the profession in all that it implies, in a year from to-day he will be so stationary that you would think he had been stationary from the beginning of the earth.

Now, a great many of the practical men of our organization have nothing but the utmost contempt for the educated engineer, due to the latter's lack of practical training. They think that an educated man is one of the most nonsensical things ever put on earth. I am reminded of the fact that it is said that the man with practice alone is worth from $1.50 to $2.00 a day; the man with education alone is worth from $2.00 to $3.00 a day; but the man who combines both educa-

tion and practice is worth any amount of money that you can get hold of. So, to the young men who have the advantages that Armour Institute offers, I say, Theorize—by all means, theorize; but do not forget that as soon as you get the principles well grounded in your minds, it will be well for you to obtain experience—go out into the world and get hold of some practice.

A graduate of a technical school once asked me to get him a job in a power house shoveling coal. I looked at him in surprise, and said, "Why, Clare, you must be 'bug house' this morning." He replied, "Not at all; I mean just what I say. I have had four years' training in this school, and now I would like to get out and earn my living." And that is the question that confronts every graduate, not only of a technical school, but of a University—What can I do to earn my bread and butter? I took this young man to the Chief Engineer of one of our large power houses, and went there frequently to see how he was getting along, for I was interested in a young man who was willing to begin at the foot of the ladder, after having graduated from one of the best technical schools in the country. The Chief Engineer told me he never had a man shovel coal so well and do it so scientifically. For three years, that young man worked himself from one round of the ladder to the next, mastered all the details of the plant, and is now one of the most successful engineers in the state, and holds a very responsible position. I believe his success is due to nothing so much as the fact that he saw the necessity of immediately taking advantage of every opportunity not only for education, but for practical training.

I am aware that education is a great thing—the greatest thing on earth to aid a man in successfully meeting and solving the problems of life; but sometimes we get education without very much knowledge. A happy combination of education and knowledge strikes me as the most important factor in technical life.

My advice to the engineers of Chicago would be: Connect your sons immediately with Armour Institute. Give them the opportunity which we lacked, and which we hope to make up in a measure by the National Association of Stationary Engineers, which means nothing more nor less than that we have established 440 primary schools throughout the United States for the technical education of those of us who, in our younger days, did not have the opportunity of gaining technical knowledge. Nothing can be more valuable than this higher technical training, which we so sadly needed, because the requirements of the engineers of to-day have multiplied to a wonderful extent.

The Reading of Gas Meters

A Brief Explanation of Practical Value to All Consumers

By EDWARD B. WAITE
Instructor in Mechanical Engineering, American School of Correspondence

THE index showing the number of cubic feet of gas used, is generally placed at the top of the meter. Different meters vary but little in the arrangement of the dials. For meters used in dwelling houses, as a rule, there are only three dials on the index, but some large meters have as many as five. These numbers do not include the upper dial, which is used only for testing, and which is not taken into consideration when one is reading the index.

The number of cubic feet of gas consumed is recorded by the dials A, B, and C, shown in Figs. 1, 2, and 3. This is the

most common form of index. Each complete revolution of the hand on dial A represents 1,000 cubic feet of gas passed through the meter; on dial B, 10,000 cubic feet; and on dial C, 100,000 cubic feet. It will be noticed that the hands on dials A and C move in the direction of the hands of a clock, while that on dial B moves in the opposite direction, as indicated by the arrows. This necessi-

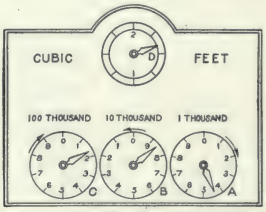


FIG. 1.

tates great care in reading, as a large error would occur if all hands were considered as moving in the same direction.

In reading the index shown in Fig. 1, begin with dial C. It will be seen that the hand on this dial is between 1 and 2, showing that more than 10,000 and less than 20,000 cubic feet of gas have passed through. The hand on dial B, being between 8 and 9, indicates more than 8,000 and less than 9,000 cubic feet; while that on dial C, between 4 and 5, indicates more than 400 and less than 500 cubic feet, but is read 400, because, as a rule, the index is read only to the number of hundred cubic feet. The amount of gas

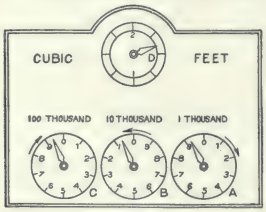


FIG. 2.

recorded by this index is therefore 18,400 cubic feet.

The reading shown by the index in Fig. 2 is 90,900 cubic feet; and by that in Fig. 3, 9,100 cubic feet.

If the reading on the index shown in Fig. 1 is taken on a certain date, and that on the index shown in Fig. 2 on a later date, the difference between the two readings will show that 72,500 cubic feet of gas have been used during the time that has elapsed between the two readings.

If the hand on any dial appears to indicate a figure exactly, look at the dial next lower in denomination. If its hand has passed zero, then use the number indicated, but not otherwise. It is never necessary to reset registers.

When the hand on the dial of highest denomination has made a complete revolution, the hands on all the dials will point to zero. If one reading is taken before, and one after this relative position of the hands has been reached, then, to find the amount of gas consumed, the earlier reading must be subtracted from the total formed by adding the total

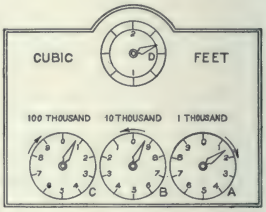


FIG. 3.

registering capacity of index to the later reading.

In reading the index on larger meters, where more than three dials are used, no difficulty should be encountered, since each dial is labeled with the number of cubic feet represented. It must be kept in mind, however, that the hands on alternate dials revolve in opposite directions.

The above is also the method of reading the index of the ordinary water meter. Usually, however, the quantity of water used is recorded in gallons instead of cubic feet. To transpose gallons to cubic feet, divide by 7.48; and to transpose cubic feet to pounds, multiply by 62.4.

Lost Treasures of Art

Mysterious Disappearances of Valuable Works of Art, for Whose Recovery Fabulous Sums Would be Paid

A WRITER has compiled in a recent number of *The House Beautiful* some interesting facts regarding the unaccountable disappearance of valuable art treasures at various times in the history of artistic activity.

The greatest treasure in sculpture the world has ever known is imperfect, and any one of the pieces missing would bring the finder a king's ransom. They belong to the Venus de Milo, now in the Louvre at Paris; and twenty-eight years ago the most important of them—the right arm—turned up in England, and was proved by experts to be a genuine part of the Venus. The owner, however, refused to part with it, and concealed it somewhere lest it should be stolen by thieves. When he died he left no record as to where the arm was hidden, and from that day to this its resting-place has remained a mystery.

Somewhere there is an old bronze drinking-cup which would easily realize $100,000 if put on the market. It is the famous bronze bowl found in Egypt a century and a-half ago, on which was engraved the ancient history of the Pharaohs. It was stolen from an Egyptian temple in 1739, and brought to Europe. From that time it strangely disappeared, and forty years later the French Government offered $14,000 for its recovery; but the famous cup had vanished, in all probability forever.

Great pictures have an unhappy knack of disappearing, and lucky would be the individual who should find Sir Joshua Reynolds's "Countess of Derby," for it would realize $150,000. This was acknowledged to be Reynolds's greatest portrait; but not long after it was painted it disappeared from the Earl of Derby's collection, and has never since been heard of. There are also two Vandykes and a Rembrandt missing, for which collectors would willingly pay $200,000; and no doubt the Earl of Crewe would give a five-figure reward to anyone who restored the Cupid cut by some vandal from the picture of a former Countess of Crewe and her son, the latter being painted as a little sprite.

Half a century ago the Italian Government offered $50,000 to anyone who would rediscover the Florentine chalice. This is a goblet of green Venetian glass made in the sixteenth century for the Pope and engraved with a picture of the Resurrection. Its manufacture is said to have occupied two years, and the secret of the glass, which was thinner than paper, is lost. The cup was stolen from the Vatican. But no one came forward to claim the offered reward, and the probabilities are that the cup has been destroyed.

A similar treasure, which vanished in an equally strange manner, was the Marsella vase of Dresden china. It is the only piece of china missing from the famous Marsella collection, the value of which is set down at $75,000, and it bears upon it the cross-arrows and a lion's head. A few years ago the vase was said to be in the north of England; and it is safe to assert that if anyone rediscovers it he can command a price running well into four figures.

Probably in some lumber-room in England there is an old sword which, if the owner only knew it, is worth eight or ten thousand dollars. It was the State sword presented by the nation to Edward III., and at one time the hilt was studded with large rubies; but these disappeared long before the weapon followed them. Any one of the British national museums would purchase the sword for the sum mentioned, while it is not unlikely that in a public auction room the bidding would rise even higher.

The Mechanism of the Telephone

II.—A Description of Circuits, Batteries, Magneto-Generators, and Other Details of Installation

By HARRIS C. TROW, S. B.

Instructor in Electrical Engineering, American School of Correspondence at Armour Institute of Technology.

THE earliest form of telephone circuit consisted simply of two Bell receivers connected in series. The one which was being used as a transmitter served as a very small generator which sent alternating currents over the line, and these acted upon the instrument at the other end of the circuit, which was, for the time being, used as a receiver.

After the invention of the carbon transmitter the circuit consisted of a transmitter and receiver at each end of the line, together with the batteries which furnished the power, all connected in series. This arrangement did not give satisfactory results, for many reasons, but the use of the induction coil overcame the difficulties previously met with.

A typical circuit with the induction coil is shown in Fig. 5. Here T is the transmitter, B the battery, P the primary and S the secondary of the induction coil; and R the receiver. The primary circuit contains the transmitter, batteries, and primary of the induction coil, while the secondary circuit contains the receiver and secondary coil. When the transmitter at one end of the line is spoken into, the resistance of the primary circuit

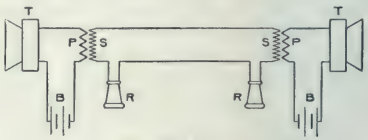


FIG. 5.

is varied, and this in turn varies the strength of the current passing through the primary of the induction coil. Consequently alternating currents are induced in the secondary coil, which pass over the line and act upon the receiver at the opposite end.

The induction coil used in telephone work has a core made of soft iron wires. Upon this is wound the primary coil, consisting of a comparatively small number of turns of coarse insulated copper wire; and outside of this, and carefully insulated from it, is the secondary coil, in which are a great many turns of fine insulated copper wire. Without the induction coil, it is probable that the long-distance telephone in its present state of perfection would have been impossible. Its use allows the resistance of the circuit in which the transmitter acts to be very small; with the result that the effects of the variations in resistance due to the

MR. HARRIS CUSHMAN TROW, the writer of this article, has an established reputation as a practical electrical engineer. He is a native of Massachusetts and a graduate in Electrical Engineering of Tufts College. This specialty he has for years been teaching. He is also a graduate of the Sloyd Training School, Boston, the pioneer Sloyd Training School in the United States and the most famous school in America representing the educational features of manual training; is an associate member of the American Institute of Electrical Engineers; and has been a frequent contributor to technical journals.

transmitter are comparatively large. This low resistance also permits a larger current to flow with a given number of cells of battery. The electromotive force of the secondary current is high, thus being well adapted to overcome the high resistance of the receivers, secondary coils, and line wires. Still another advantage lies in the fact that if the transmitter were connected directly in the main circuit, its effect would be to cause the current in the line to vary in strength but not to change in direction. In other words, the current would be undulating but not alternating. However, better results are obtained if the current which actuates the receiver is an alternating one, and this is of course the nature of the current in the secondary of the induction coil.

Batteries

In telephone work the batteries are required to furnish current for only short periods of time, and the Leclanche cell is admirably adapted for the purpose. It requires very little attention and will furnish a comparatively large current for a short time. Moreover, although these batteries polarize in a short time if kept on a closed circuit, they recover very quickly when the circuit is opened.

The Fuller cell is also used to a considerable extent. In this cell the plates are zinc and carbon; dilute sulphuric acid is the excitant, and either bichromate of sodium or bichromate of potassium may be used as the depolarizer. The zinc is placed in a porous cup, in the bottom of which is a small quantity of mercury, which serves to amalgamate the surface of the zinc and thus prevent local action between the zinc and the impurities that it contains. This cup is then filled with a solution of sodium chloride (or common salt) dissolved in water. In the battery jar is the solution of dilute sulphuric acid and bichromate of sodium or potassium. The porous cup is put into the jar, and the carbon suspended through an opening in the cover which fits over the jar. This cell is excellent for telephone work; it has a high voltage, low internal resistance, and does not deteriorate on open circuit.

The gravity battery and the storage battery are used in telephone work when constant service is required. Dry cells are also used extensively, particularly in intercommunicating sets, on account of their cleanliness and convenience.

Magneto-Generators

The above-described equipment serves to transmit and receive messages, but it is also necessary to supply some sort of calling device. The simplest apparatus for this purpose consists of an ordinary bell or buzzer, operated from batteries, and this system is used commonly to-day for office sets where the distance between stations is small.

For long distances it is, however, impracticable to use this system for calling, and recourse is had to the magneto. This consists of a generator having permanent field magnets, and a shuttle armature which is wound with many turns of fine insulated copper wire. The armature is rotated at high speed by means of a small pinion on its shaft, which meshes with a larger gear that is turned by means of a crank. This machine furnishes an alternating current, and hence it is necessary to use a polarized bell or ringer in connection with it, so constructed as to operate with an alternating current. Magneto-generators are designated by the resistance through which they will ring, being spoken of as a 10,000-ohm, 20,000-ohm generator, etc.

At the exchange it is quite common to use a power-driven magneto-generator, which may be driven from a small direct- or alternating-current motor. Also in some cases the motor-generator is used to supply current for ringing purposes.

Circuits of the Telephone

A complete telephone set is made up of three distinct circuits: one for the calling apparatus, one for the transmitting apparatus, and one for the receiving apparatus. The calling apparatus includes the generator and ringer, the transmitting apparatus consists of the transmitter, batteries, and primary; and the receiving apparatus consists of the receiver and secondary of the induction coil.

When the telephone is not in use the calling apparatus must be connected with the line while the transmitting and receiving circuits are both open. On the

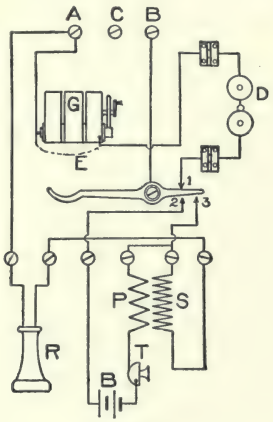


FIG. 6.

other hand, when the telephone is used for talking, the calling circuit should be opened, the transmitting circuit should be closed, and the receiving circuit should be connected to the line. These results are accomplished automatically by means of the switch-hook upon which the receiver is hung. This hook is depressed when the receiver is in place, and raised by a spring when it is removed. In this manner the desired connections are made at the proper time.

There are two types of telephone, differing somewhat in the details of their construction and connections, known as the "series" telephone and the "bridging telephone."

The circuits of the series telephone are shown in Fig. 6. A and B are the line terminals, and C the ground connection for the lightning arrester. When the receiver is on the hook, the switch is in the position shown. The generator G and ringer D are in series across the line, through contact point 1, the generator being automatically cut out by the shunt E when not in use. When the receiver is removed, the contact at 1 is broken, and contact is made at points 2 and 3. The primary circuit is then closed on itself, while the secondary circuit, containing the receiver and secondary of the induction coil, is cut in on the line.

Below there are three pairs of binding-posts, to one pair of which the receiver R is connected. To another are connected the terminals of the primary circuit containing the transmitter T, the battery B, and primary P of the induction coil, while the secondary S of the induction coil is connected to the third pair.

Connection is made to the bell through the hinges of the box upon the door of which it is mounted. It is customary to use a ringer of 80 to 120 ohms' resistance with series telephones. On account of this low resistance many series telephones cannot be bridged because it would be impossible to ring a number of them in multiple. Moreover, many series telephones could not be connected in series because, since all the ringers would be constantly in the circuit, it would be impossible to talk through them. Hence this type of telephone is used almost exclusively for city exchange work, not more than two telephones being connected on a line.

The circuits of the bridging telephone are shown in Fig. 7. The ringer coils are permanently bridged across the line.

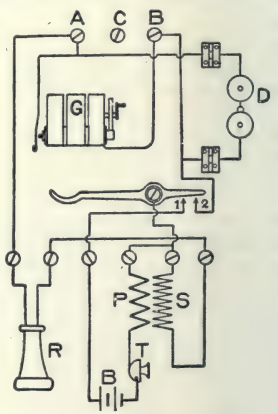


FIG. 7.

The generator is also bridged, the circuit through it being open when it is not in use, but being closed, usually automatically, when the generator is in operation. When the receiver is taken from the

hook, contact is made at points 1 and 2 for the primary and secondary circuits, as in the series telephone.

The permanently bridged ringer does not interfere with the action of the receiving circuit, since its coils have a resistance of about 1,600 ohms and are wound so that their self-induction is large. Thus they offer a high impedance to the currents in the receiving circuit because of the extreme rapidity with which they alternate. For this reason a number of these telephones can be bridged upon one circuit, thus forming a party line.

There are three general methods of constructing lines, namely, the grounded circuit, the metallic circuit, and the common return. In the common return the circuit is completed through a copper wire, instead of through the ground as in the grounded system, thus eliminating the noise induced by earth currents.

Of late years great improvements have been made upon the telephone in respect to the location of battery and the manner of signaling. A large storage battery at the central station furnishes the current for all transmission, as well as a means of signaling central. This, of course, calls for a partial inversion of mechanism and dispenses with the generator and battery at the subscriber's station, which greatly reduces the cost of construction and operation and the liability of the telephones to get out of order. These central energy systems are rapidly replacing the magneto telephone in general practice.

Pressure on Engine Guides

An Explanation of an Important Detail Affecting the Design of Steam Engines

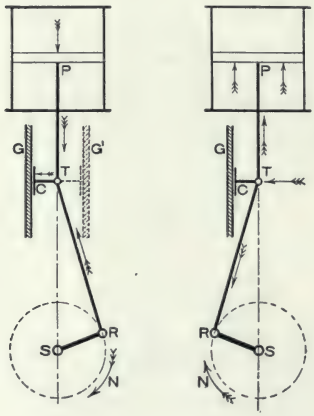
THE most common form of steam engine is that in which the steam drives the piston back and forth in a straight line in the cylinder, and this motion is converted into rotary motion by means of the connecting rod and crank.

The motion of the reciprocating parts of a vertical engine is illustrated in the accompanying figure, one diagram representing the down stroke and the other the up stroke. In these diagrams, P represents the piston, P T the piston rod, T R the connecting rod, R S the crank, and S the shaft. The end T of the piston rod is made to move in a straight line by the guide G.

Suppose the engine to be moving in the direction indicated by the arrows N N. The piston is driven first in one direction and then in the other; but for either direction the force acting along the piston rod P T is resisted by the propeller or the machine connected to the shaft. This produces tension or compression in the connecting rod according to the stroke. The arrows indicate the direction of these forces. The forces acting in the piston rod and connecting rod produce a resultant force at the crosshead, which is toward the guide, for the direction of rotation shown by the arrows N N. While the engine is turning in this direction, the pressure is on the guide, as shown, during both strokes. If, however, the engine turns in the opposite direction, the crosshead tends to leave the guide G, or, in other words, the resultant force acts in the opposite direction. The force acting at the crosshead is resisted by the guide.

By turning the figure to the left through an angle of 90°, we get the diagram of the horizontal engine. In

engines of the horizontal type, the crosshead is usually between two guides, a lower and an upper guide, as shown by the dotted lines. If the stationary engine is run in the direction indicated by the arrow, it is said to be running *over;* while if running in the opposite direction, it is said to be running *under.* Most engines are designed to run over because, as shown above, the pressure is always on



the lower guide. This insures smoother running, since, when the crosshead becomes worn and fits loosely, there will be no bad results, such as knocking of the crosshead against the guides.

If, on the other hand, the engine runs under, the pressure between the guide and crosshead will be upward. At both ends of the stroke, the piston and crank are in a straight line, and therefore there is no pressure on the guide. Consequently in engines which run under and which have a loose-fitting crosshead, the pressure will be on the upper guide, except at the ends of the stroke, when it will immediately drop to the lower guide because of the weight of the crosshead. In this way a knock is sometimes caused.

This is what would take place in engines if steam were admitted during full stroke, and exhausted during the entire stroke. In actual practice, however, steam is admitted only during the first part of the stroke, and expands in the cylinder until near the end of the stroke when it is allowed to exhaust. On the return stroke, the piston forces the steam out of the cylinder through the exhaust port; but when the piston is near the end of the stroke, the exhaust valve is closed, and the steam which is left in the cylinder is compressed. The object of this compression is to cushion the reciprocating parts, such as the piston, piston rod, and crosshead. The back pressure at the end of the stroke causes the direction of the pressure on the guide to change from that as explained by the above diagram. Therefore, near the ends of the stroke in engines running over, the pressure on the guide actually does change its direction; but the advantage in favor of running over is that in this case the weight of the crosshead is acting towards the lower guide and giving pressure on it; while in running under, the weight adds to the force tending to change the direction of the pressure on the guides. It follows, then, that in engines which run over, although the pressure is not always on the lower guide during the entire stroke, yet there is smoother action and less knocking of the crosshead against the guides.

Looking for the Silver Lining

A Lesson for Us All

IN less than a week the fortunate ones who live in the country will see and hear the hermit thrush—a bird somewhat smaller than the common sparrow, with dark-brown feathers and speckled breast—the very picture of grace as he sits on a bough in some woodland green making the grove echo with his cheerful singing.

To those who have heard the hermit thrush his warbling will never be forgotten. It consists of a succession of notes greatly diversified, repeated at short intervals, with variations, loud, clear, mellow, and at times melting and tender. One of the peculiarities of this little bird is that he sings in all kinds of weather. Not only when the day is bright and clear does this little songster warble his wood-notes wild, but in the midst of fog, a drizzling or a heavy rain, the hermit thrush will take his stand under cover of a projecting rock, or beneath the boughs of some spreading tree, and for hours make the whole country-side ring with his matchless music.

The Hermit Thrush an Optimist

The hermit thrush is an optimist; in other words, the fact of his singing in all kinds of weather would indicate that part of his mission in the world is to teach cheerfulness.

While it seems almost impossible amid the pressure of our modern life to attain such a mastery over ourselves that the disagreeable experiences and burdens of life will never discourage, yet I am persuaded that a man's real life, should he so desire, may be made secure against most of those outside forces which depress and discourage.

Cheerfulness a Virtue

"Sandy, what is the state of religion in your town?" asked a certain gentleman of an old man. "Bad, Sir, very bad," was the reply. "There are no Christians except Davis and myself, and I have my doubts about Davis." Sandy was a pessimist and practiced the detestable habit of fault-finding—a habit far too common, as all good-natured people know. Cheerfulness ought to be proclaimed as one of the cardinal virtues, and its practice made a duty. For a good every-day companion, commend me to the man who can laugh—who can bear trifling disturbances with cheerfulness, and can see a humorous side to even a very disagreeable situation. The world is very much what we make it. God made it at the start, but man is making it over again. The trick of always seeing the bright side is a faculty that can be cultivated; and if we are not born, as the Irishman said, "with a ray of sunshine in our heart, we can have even so much as a tallow candle that can be snuffed, and coaxed, and trimmed into a light that may help someone." Wonderful beyond estimate are the resources of cheerfulness. A cheerful man will accomplish more in a given time, and be less fatigued, than a pessimist associate, even though a moderate advantage of skill be on the side of the grumbler. Carlyle, that master of English prose, was right when he said, "Give me the man who sings at his work."

How to Bring Smiles

People who think that there is nothing colder than a dog's nose should try to get a smile out of the man who is always looking on the dark side. It takes so little to make the average man happy; and yet the majority of us are very poor hands at cheering up a friend when he is down-hearted, from the reason that we usually tell him to count up the mercies that are around him, when, nine times out of ten, we should do far more good by telling him the help and comfort he has been to others. If things have gone wrong and a fellow-workman comes to the shop looking tired and discouraged, it won't cheer him half so much to preach that he ought to be thankful for the many blessings that surround him; but if you tell him what a good worker he is, and how much he has done for his shop-mates, it will bring the sunshine to his face in a moment.

What's Wrong with the World?

The trouble in this world is a good deal like the verdict of a certain jury in a burglary case. "Gentlemen of the Jury," asked the clerk of the court, "have you agreed upon a verdict?" "We have," replied the foreman, "the verdict of this jury is that the lawyers have mixed this case up so that we don't know anything at all about it."

Moralists and philosophers have so swamped the world with their fine-spun theories of living that we have passed over the fact that the chief end of man is to be happy—to enjoy life, to generate sunshine in his pathway from the cradle to the grave—and when a man fails in this, he fails in his duty toward his fellow-man.

"If you have caused one tear the less
Down sorrow's cheek to flow,
If you have caused one smile the more
On any face to glow,
Then, Friend, you have not lived in vain."

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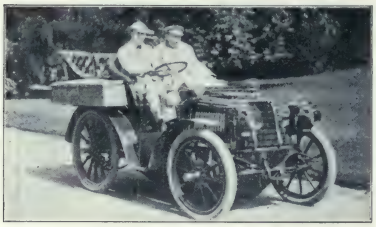
Col. Visscher on Automobiling*

COL. WILLIAM LIGHTFOOT VISSCHER, the veteran poet, humorist, and newspaper man of the West, visited New York recently, when he had his first ride in an automobile. Describing his experiences in a letter to his old chum, Buffalo Bill, he writes as follows:

"New York, September 12, 1903.
"Col. W. F. Cody, 'Buffalo Bill.'
" 'Way Over Yan.

"Dear William: Say, it was a close call for me when I saw your picture in one of those scoot-wagons and no horses hitched to it, and you at the pilot wheel. Now I have been there myself.

"Out in Chicago, Jimmie Hall took me to supper one night, down where he lives



THE COLONEL LOOKING LIKE "HAPPINESS ON TAP."

on Grand Boulevard. He called up one of those hackmobiles, and we were shut up in it like a Black Maria. Besides the night was as black as a stack of black cats and I didn't see—none whatever.

"This was different. I saw it all.

"You see, I struck it pretty rich in the Panaheap; and when I hit here with a fifty-dollar Panama and a suit of cream-white flannels on, I looked like a stock of blues on a dead-sure, whipsaw turn, and now I've got things where I don't propose to stay out of the game at any stage. So, go-quick horseless is next.

"I flashed a roll about as big as an elephant's leg while I was talking to the man at the gasoline livery stable, pretending as if I was hunting for my credentials or something; and in no time a fine young fellow—Jimmie Chaffer, I think they called him—had out a four-seated red rascal, and we went—well, didn't we went!

"Say, Bill, that was the first real ride I ever had in all my checkered—and you know that I have split the rarified atmosphere of the Rocky region and elsewhere on bronchos that thought they had a contract to fly like a ricochet shot that only hits the high places.

"This little whizz-board that Jimmie Chaffer and me were on was named the 'Panhard,' and it had a 12-horse-power go to it. But I gave it another name. I named it after Byron's dog, 'Perchance.' Some people want to know how I got on to it that Byron's dog had that sort of a handle. Don't he say 'Perchance my dog?' That's what he does, and this flying wedge of a wagon is hereafter just Perchance, because I got it perchance, and, moreover, there were times when I thought perchance Jimmie Chaffer and me would get killed so dead that we'd spoil before the crowner could sit on us.

"At the start, after we left Mr. Robertson and the Auto-Exchange Storage on Thirty-eighth street, we poked along among a herd of street-cars and subway excavations, and citizens on foot and in carriages, piles of rolling-mill output, and other. I could see Jimmie Chaffer was chafing some, but he held in plenty though now and then he'd make a *chassez* for a spurt of ten or forty rods that were clear, and he would make Perchance cut around a baby in the block, or a weary old lady with a basket, till the baby would grin wholesome, and the old lady would look wild, and side-step, active. One time Jimmie cut around a spectacled professor—who was conning the Whichness of the Whence, all by his lonesome—just like a champion skater working for a record in scrolls. All of which showed me that people and vehicles, babies, women, professors, men on the jump, laundry wagons, jay-busses, turnouts, apple-carts, and push-gigs were safe enough with

*Courtesy of "Automobile Topics."

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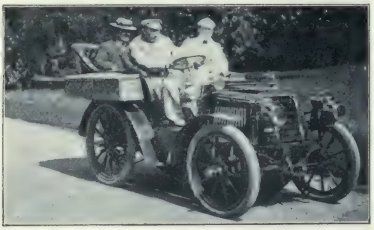
Jimmie Chaffer and Perchance, and that your Uncle Johnny was all right for Montana, when he sees fit.

"But say, Bill, when Jimmie Chaffer had worked Perchance by jumps, curves, slow-ups, and start-quicks, through those wedge-ins and other intricacies, and hit Central Park drives, he made scenery look like it was running a race with a cyclone. He'd take a quick sight over his left to see if a park protector was rubbering the procession, and then he'd let Perchance pass over the pike. Those winding roads went under the tires like fly-wheel bands in an electricity factory, and



BUT WHEN HE TOOK THE WHEEL, HAPPINESS WASN'T IN IT.

the greenwood slid by, *en masse*. You should have heard your Uncle Billious holler. I did want to shoot out some lamps, bad, but Jimmie Chaffer said that wasn't 'ong-ragel' and 'o-fay,' and a few other things, from which I gathered that it wouldn't do, with so many timid parties present—just present for a second. So I refrained from celebrating in that manner. But I was elated, and I want to tell you that I've cinched myself tight to say it that easy.

"Well, we shot anyhow. We shot through the park as if we were going for the doctor to attend a train-load of folks that had stopped too sudden. I filled my lungs full of ozone and my soul full of enthusiasm. We didn't have any other filling—didn't need it.

"After we struck the streets again Jimmie lined up Perchance alongside the curb and got out to take a snap-shot of me with a kodak. That's the only sort of thing that your Uncle Billious will be shot at with and not recip.

"Jimmie said he wanted the picture of me to hang up at home, to make the place happier, because, he said, I looked like happiness on tap, and he called the turn, but Perchance was the stimulant. He let me hold the pilot-wheel so that it would look as if I were gee-hawing Perchance. But I want to say to you that while there have been times when riding gauntlet through a lane of Sioux might have been undertaken with some hope, there wouldn't be much left, whole, *en route*, if your Uncle Johnny undertook to steer Perchance over the trail that we took.

"In a forthwith manner we slid down Fifth ave., and Jimmie told me whose tepee this was and what heaven-gate that was, and he mentioned the make-up and might of other auto-goers that we passed —passed is the word.

"From my friend Holland's brick house on Fortieth and Broadway, we went to Harlem so quick that an observation car would have been useless. From Central Park to the Flatiron that shows so many ruffles at Twenty-third street, we were so instant along the way that I couldn't ask who lived anywhere before we had passed the point. We shot around Madison Square Garden, got a whiff of the rum-blossoms and other bouquets that bloom in the place—tra-la, and then we turned up Broadway. A number of friends saluted me and I waved them in a way that said: 'This is not only frequent, it's a habit.' Now they think more of me than they did.

"At one place Jimmie ran Perchance in a circle not bigger than a good-sized hoop-skirt, around a lamp-post. He said he did it to avoid frightening a lady with a bobtail electric runabout, who had a look of alarm and considerable red paint on her face. But I think Jimmie just did it to show the circumscribed circumference in which he could twist Perchance.

"Anyhow, I saw enough on Perchance to know that the auto-wheel is the thing that ought to be, more than it is. It is the safest thing that ever has been worked out, up to the time of going to press; and while Mr. Horse is all right in his place, his place is not so much in the city. Jimmie could stop Perchance in the space that a horse couldn't if he dropped dead.

Fact is, Perchance is all right, and your Uncle Johnny will ride one of 'em home after he gets on to the curves, if the Panaheap don't pinch out.

"Yours affectionate,

"JOHN A. KUMLATELY."

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The Gearing of Lathes for Screw Cutting

An Explanation of an Important Shop Problem.

By P. J. KASPAIE

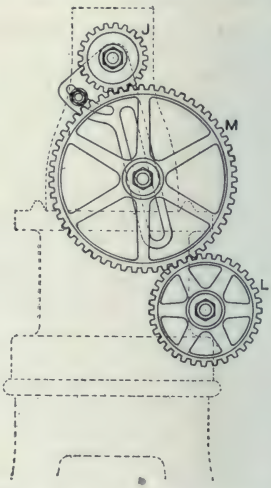
A Student of the American School of Correspondence.

THIS is a problem that has been confronting many machinists and apprentices who have served their time in shops where only up-to-date machinery has been used, but most of the small shops are still equipped with the troublesome lathes in which the gears have to be figured out before a thread can be cut.

I shall now attempt to give a definition on the subject. The problem of cutting a screw on a lathe resolves itself into connecting the lathe-spindle with the lead screw by a train of gears in such a manner that the carriage advances just one inch while the lathe-spindle makes a number of revolutions equal to the number of threads to be cut per inch. The lead screw in most cases has a single thread which causes the carriage to move one inch to the number of revolutions equal to the number of threads on the lead screw. If the lead screw has a double thread, it will make a number of revolutions equal to half the number of threads cut per inch, to accomplish the same result. We must first know the number of threads per inch on the lead screw.

It must be clearly understood that one or more intermediate gears simply transmit the motion received from one gear to another, but do not change the ultimate ratio of a train of gears. An even number of gears changes the direction of rotation, but an odd number does not alter it.

In the figure we have a case of simple gearing. In simple gearing, the motion from gear C is transmitted either directly to the gear on the lead screw, or through the intermediate gear F. We shall consider only simple gearing, and shall express the number of teeth of the different gears by their respective letters.



Let S = threads per inch to be cut.

Let T = threads per inch on lead screw.

Then,

$$\frac{S}{T} = \frac{L}{J}.$$

If, now, one of the two gears J and L is selected, the other will be:

$$L = \frac{S\,J}{T};\ \text{or,}\ J = \frac{L\,T}{S}.$$

Thus, if the lead screw has 6 threads, and a screw is to be cut with 12 threads per inch, and we select gear L with 48 teeth, then J must have

$$J = \frac{6 \times 48}{12} = 24 \text{ teeth.}$$

LAST CHANCE

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Graduate and Student Notes

SECOND ANNUAL RECEPTION

ON the evening of Friday, June 17, the Armour Institute of Technology will hold a reception for the students of the American School of Correspondence, and Senator Dolliver of Iowa will deliver the principal address. At last year's reception, 5,000 enthusiastic American School students were present and demonstrated in a hundred different ways their appreciation of the work of the School.

On June 17 a delightful evening is in prospect for our students. No man in the United States is better qualified by scholarship and by experience in public affairs to discuss the problems and opportunities of the industrial world than Senator Dolliver. For many years, in the House of Representatives and in the Senate of the United States, he has taken a leading part in every important trade development before the nation. It is indeed an honor to the American School students that the Armour Institute should secure so widely known a speaker for the reception. Dr. Gunsaulus will preside and will also speak. After the meeting, guides will be in attendance to conduct the students through the buildings of the Armour Institute and the American School.

Be sure to make a note of the date, and do not fail to be present. This is another opportunity for our students and their friends to become acquainted with the members of the faculty of the Armour Institute of Technology and the American School of Correspondence, and also to hear Senator Dolliver and Dr. Gunsaulus—two of the best known public men of the age.

We hope that a goodly number of American School students from other parts of the country will arrange to be present at the reception. Last year a large number of students attended from other towns, and enjoyed the exercises very much. Try if possible to adjust your affairs so that you may be present June 17th, and spend the day visiting the schools and laboratories and in the evening attending the reception.

A Word from the Editors

THE Editors are anxious to make THE TECHNICAL WORLD of the highest possible service to American School students. For this reason, they invite every subscriber to send in suggestions as to the character of the articles he considers most desirable and what departments he would like to see enlarged. *See blank form for suggestions, published among the advertising pages in the front of this number* (page *viii.*) Tear that page out, and send it to the Editors, writing frankly your views on the points indicated.

It is only by getting our students' ideas as to their needs, etc., that we shall be able to make THE TECHNICAL WORLD what it was intended to be—the best technical magazine to meet the needs of our students, and to reflect all important advances along technical lines that are worthy of being brought to general attention. Do not fail to write, and do not be afraid to criticise any article or department. Your suggestions will be received in the kindest spirit.

Exercise at Home

We are successfully teaching men and women in every part of the world **The Stone Method** of Scientific Physical Culture. It requires only 15 to 20 minutes time each day, in your own room, just before retiring, or upon arising. No apparatus whatever is required, and you will be put to no expense aside from our modest fee. Individual instruction is given in every case, which is based on the pupil's present condition, habits, mode of living, and the object which he wishes to attain. By **The Stone Method** of concentrated exertion, more exercise is actually obtained in 20 minutes, than by the use of apparatus for two hours. The exercises are rational, moderate and are taught by an instructor who is thoroughly versed in physiology, and who has been prominent in athletics and athletic training for 32 years. **The Stone Method** does not overtax the heart. Our pupils are of both sexes and range in age from 12 to 85 years.

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It is the duty, and should be the pleasure, of every mother to take a course in scientific physical culture, not alone for the benefit which would result to her own health, but that she may in turn instruct her children and bring them up to be strong, healthy, robust men and women. **Booklet, Testimonials and Measurement Blank FREE.**

The Stone School of Scientific Physical Culture,
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FREDERICK W. STONE,
Director of Athletics of the Stone School of Scientific Physical Culture was formerly Instructor of Athletics of Columbia College and the Knickerbocker Athletic Association, New York (afterwards called the Manhattan Athletic Association), and was also director of athletics in the Chicago Athletic Association. At the age of 32 years, he is still a physically perfect man. He established the world's record for 100 yards sprint (9 4-5 seconds); he has been before the public 32 years as an athlete and instructor in physical culture, and, it must be admitted, is thoroughly qualified to teach others the science of self-development.

Special instruction given in deep breathing without extra charge.

CHILLICOTHE, O., June 2, 1901.
When I first wrote you in regard to your method of exercise I was on the verge of nervous prostration. Six weeks exercise has worked wonders. The extreme nervous depression, headaches, insomnia and lack of appetite have all disappeared. Muscles are larger and firmer, powers of endurance much increased. Your method has gone right to the spot.
E. J. POWELL.

SOUTH BEND, IND., Aug. 3, 1901.
No one could help but derive great benefit from your course. After five weeks practice I went with a party of five to the Pan-American. I stood the trip with less fatigue than any one else in the party and it was due to having taken your exercise daily.
Yours truly, LAURA J. GUNT.

THE Editors take pleasure in announcing that Mr. John Cohoon, of Paterson, New Jersey, was the first student to suggest the name adopted by this Magazine —THE TECHNICAL WORLD. In acknowledgment of Mr. Cohoon's services, a set of the "Reference Library, Modern Engineering Practice" has been presented to him.

The hearty co-operation of our students in the selection of a name, and the large number of subscribers we have enrolled through their influence, have been most gratifying to the officers of the American School. The Editors, as a token of their appreciation, will use every endeavor to make THE TECHNICAL WORLD an organ of practical helpfulness to all interested in technical lines.

ALL GRADUATES of the American School of Correspondence who have not yet sent their photographs to THE TECHNICAL WORLD are requested to do so at their earliest convenience.

A Club in Buffalo

THE welcome extended to Dr. Colledge and Mr. Oliver C. Miller by the Buffalo students of the American School of Correspondence was exceedingly gratifying. Many called at the hotel, and several pleasant evenings were spent chatting about the work of the School, the studies of the men enrolled, and the prospects of forming a club in Buffalo.

On the evening of Dr. Colledge's lecture, between 800 and 900 men gathered in the Peck Assembly Room and listened to an address from the Dean. After the lecture, an informal reception was held in the hall, many remaining to renew acquaintance with Mr. Miller and shake hands with the Dean. Mr. Miller remained several days in Buffalo before returning to Chicago.

A Students' Club is about to be organized in Buffalo, and we trust that all of our students will take advantage of the opportunity to become members. There is no question about the helpfulness of such organization, and we are certain that the club will prove so valuable that in a few months every student in Buffalo will have joined.

Dr. Colledge lectured in Syracuse on the evening of March 15. A heavy snowstorm limited the attendance to about 100 students and their friends. After the lecture a pleasant half hour was spent. The American School of Correspondence has a number of earnest students in Syracuse who are doing excellent work, and we hope the time is not far distant when they will be able to organize a club similar to the one that is now being formed in Buffalo.

Dr. Colledge in Philadelphia

ON March 3, at the annual meeting of the Religious Education Association, held in Philadelphia, Pa., Dr. Colledge, Dean of the American School, delivered an address entitled "The Present Use of Correspondence Instruction." The address opened with the following significant words:

"Instruction by correspondence is a phase of education the scope and importance of which few but those who are actively engaged in the work apprehend. Reasonable investigation will quickly convince the doubter that this form of instruction has a large place in the education of the future. Apart from the value of instruction by correspondence as an educational force, the character of the students will always give to it importance.

"This form of education is carrying a message of culture and training to men and women who at this hour are engaged in the activities of the nation—active workers in the country's trades and professions, where training and technical knowledge are necessary to promotion. The young man attending school or college may be an important factor in society's activities three, five, or ten years hence, but to-day he is a school-boy.

"On the other hand, the average correspondence student is a living, breathing, working unit that society every day of its existence has to reckon with. For this reason, instruction by correspondence has as important and responsible a mission as any other phase of education. Its province is to teach men and women who are self-supporting units —who are taking an active part in the struggle of existence."

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OUR EXHIBIT AT ST. LOUIS

SINCE the last issue of THE TECHNICAL WORLD, much has been done to advance our St. Louis Exhibit. By the time this number is in the hands of its readers, the booth will be erected in the space provided in the Electrical Building, and everything in connection with our exhibit will be in "apple-pie" order.

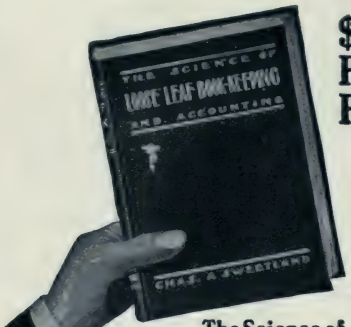
The accompanying cut illustrates the elevation of the booth designed by Professor Gardner of the Massachusetts Institute of Technology.

Students throughout the country have given an enthusiastic coöperation in the preparation of the exhibit. Specimens of their work, drawings, electrical apparatus of various kinds—all of special interest in engineering—will be there for inspection.

The Electrical Building is situated on the left of the Grand Basin, looking toward Festival Hall. Our exhibit is in Section 19, Aisle "Y," and we trust that every student visiting the Fair will make his headquarters with us.

Several of the interesting pieces of apparatus, etc., sent in by our students, might be mentioned here.

Mr. Arthur Brake of Chicago, Illinois, has loaned a small half-horse-power engine which he designed and made himself. Although a miniature in size, the engine runs perfectly.



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"I beg to acknowledge receipt of your valuable book am well pleased with it. You have certainly conferred a great benefit upon the book-keeping fraternity by the timely publication of your work upon the loose-leaf accounting system."

Dec. 19th, 1903. P. O. WHITTOCK.

GRADUATE AND STUDENT NOTES—(Continued)

Mr. Ridley, who is connected with the Fort Wayne (Indiana) Electric Company, has sent a high-tension voltmeter switch, which is a beautiful specimen of work.

Mr. Bruce Sidmore of Barberton, Ohio, has made a large drawing of a 175-horse-power sterling boiler. The work is of high character, the subject having been handled in a masterly manner.

Mr. C. L. Kinport of Minneapolis, Minnesota, has submitted drawings for an architect's arcade, which are, it is needless to say, most interesting, and a great credit to the man who made them.

Mr. J. C. Fuller of East Moline, Illinois, has submitted a most excellent drawing of a coal conveyor which he has patented. Not only is the idea itself a most unique and excellent one, but the drawing is executed in a most creditable and at the same time artistic manner.

Mr. George P. Scott of Schenectady, N. Y., has sent in a number of well-executed drawings on steam cylinders, steam whistles, etc., all being good samples of Mr. Scott's work, which is always of high character.

Mr. B. A. Slocum of the Boston Machine Works at Lynn, Mass., has forwarded a very important drawing of an automatic butt-drilling and grooving machine. This drawing by Mr. Slocum has already attracted a great deal of attention.

These are but a few of the great many items that have thus far been received; and by the time the Exposition is ready to open its gates, the School hopes to have the exhibit well furnished with specimens of the students' work. The main purpose of the exhibit is to bring the work of the students to the attention of manufacturers and others interested in technical work.

As a means of demonstrating the practical value of the School's instruction, certain apparatus has been prepared to illustrate particularly the Electrical phases of the work. A large telephone switchboard and a telegraph instrument will be used in connection with the School's work on Telephony. Motor-Generator, Telegraphy, and Storage-Battery work will be represented in the same manner. The School has secured a most interesting collection of photographs of students from all parts of the world, and has a number of these portraits so mounted as to make a most interesting group of types of students. A sixteen-foot map has been specially manufactured, showing the world-wide distribution of students.

Recently Graduated

The following students have been graduated from the American School of Correspondence since the last number of THE TECHNICAL WORLD was issued:

Loxterman, Harry F., Chicago, Ill.—Course: Mechanical-Electrical.

Scoates, Daniel, Milwaukee, Wis.—Course: Mechanical.

Arnold, George B., Warren, R. I.—Course: Stationary.

Burton, A. R., Green Bay, Wis.—Course: Electrical.

Comer, George W., Jordan, Wyo.—Course: Electrical.

Davis, Charles P., Elmira, N. Y.—Course: Stationary.

Dickerson, Clifton, Echo, Minn.—Course, Marine.

Hilsinger, Frank A., Killawog, N. Y.—Course: Electrical.

Hughes, Chas. S., Sparrows Point, Md.—Course: Mechanical.

Janda, Frank, Chicago, Ill.—Course: Mechanical.

Lillie, B. E., Lowell, Mich.—Course: Electrical.

Moore, Robert N., Ironton, O.—Course: Electrical.

Shrader, John, Iowa City, Ia.—Course: Special—Heating and Ventilating.

Slutz, Charles L., Los Angeles, Cal.—Course: Electrical.

Becker, A. M., Ithaca, N. Y.—Course: Electrical.

Peacock, James M., Stella, Mo.—Course: Mechanical-Electrical.

Harris, S. W., Royal Centre, Ind.—Course: Electrical.

Mitchell, Floyd K., Inman, Tenn.—Course: Electrical.

O'Connor, Walter E., Chicago, Ill.—Course: Mechanical.

Webb, Richard L., Spring Hill, Ala.—Course: Mechanical-Electrical.

Zoul, Charles V., Cincinnati, O.—Course: Mechanical.

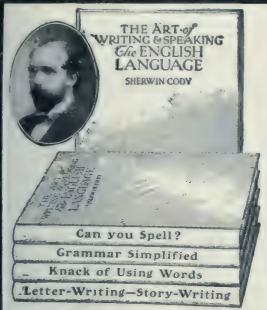
Bowring, George P. B., Lowell, Mass.—Course: Mechanical-Electrical.

Elftman, John D., Albert Lea, Minn.—Course: Stationary.

Fleagle, James E., Mayberry, Md.—Course: Locomotive.

Larson, Frederick, Chicago, Ill.—Course: Electrical.

Russell, Chas. W., Boston, Mass.; Thompson's Island.—Course: Marine.



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Nothing hampers a man like doubt about the spelling of words, about grammatical accuracy of his sentences, about whether he is using the right word in the right place, whether he is writing so as to get business.

Mr. Sherwin Cody is recognized as the highest authority on practical English in this country. His seven complete home-study courses in English, hitherto sold in typewritten form for $15.00 to $25.00 for each separate course, have now been put into four handy little volumes (pocket size, everything you want, nothing you don't want), under the title "THE ART OF WRITING AND SPEAKING THE ENGLISH LANGUAGE." Used in thousands of business offices, such as those of Marshall Field & Co., Lyon & Healy, Montgomery Ward & Co., etc.

CAN YOU SPELL?—Vol. I, Word-Study, is the only home-study spelling book ever prepared for grown-up persons. But it is more—it contains the principles of the dictionary in a nutshell, with many fine points interesting to any one.

GRAMMAR SIMPLIFIED.—If you studied grammar in school without liking it or understanding it, better take it up afresh in Vol. II, Grammar and Punctuation, where everything is simplified down to a point at which a business man can understand it at the first reading. Dr. E. Benj. Andrews says: "Your notion of simplified grammar is worthy of the widest publicity." Punctuation is treated in the same way.

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LETTER-WRITING—STORY-WRITING. Vol. IV, Constructive Rhetoric, gives the practical application of the principles of English composition to actual letters, stories, essays, etc. It contains a reprint of Mr. Cody's "How to Write Fiction," called by Zangwill "The most sensible treatise on the short story that has yet appeared in England or country that has not yet realized that story writing is an art, and a rare and fine art."

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JOHN F. GENUNG,
Professor of Rhetoric, Amherst College.

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The Phonetic Journal, London, says: "Those who take the course of lessons will have no dread of coming examinations."

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GRADUATE AND STUDENT NOTES—(Continued)

Summer School at Madison, Wis.

FOR the fourth successive year, an opportunity to acquire practical shop and laboratory experience under professional supervision is offered through the Summer School Courses for Artisans, to be conducted by the College of Engineering of the University of Wisconsin, June 27 to August 4. The following subjects will be covered:—Steam, Gas, and other Engines; Applied Electricity; Mechanical Drawing and Machine Design; Materials of Construction; Fuels and Lubricants, and Shop Work. Lectures on theory will be given, and practical work required.

The general fee is $15, besides a charge of 5 cents for each hour spent in the laboratories. The total cost for the six weeks' term need not exceed $50. A working knowledge of English and arithmetic is all that is required for entrance. For further particulars write F. E. Turneaure, Madison, Wis.

Two Useful Works

READERS will find in the "Compendium of Drawing" and the "Practical Lessons in Electricity," just published by the American School of Correspondence, two of the most useful works ever issued from the press. They are in the truest sense *working* books, embodying a mass of practical information which can be put to daily use and which is nowhere else obtainable in such compact and handy form. These books may be seen in your local public library; or, if not yet on the shelves, will be secured on a request addressed to the librarian.

Our Advertisers

THE advertising pages of THE TECHNICAL WORLD abound with hints and suggestions that will be found of great value to all who are interested in the practical solution of mechanical and technical problems—such as keeping abreast of the latest improvements in machinery, etc. Among the manufacturers and business firms who are taking advantage of our columns to bring their facilities to the general knowledge of the public, will be found responsible concerns who can meet the requirements of any problem likely to arise. If you are contemplating the erection of a new plant, the installation of new machinery or lighting, or need suggestions as to the latest and best in your particular line, it will pay you to watch the advertising announcements in our pages. The Catalogues distributed by these manufacturers display wonderful skill and ingenuity. Many of them are gems of typographical and literary art, and are worthy of rank as scientific and technical books of permanent value.

New Instruction Papers

THE Textbook Department has recently published some unusually good Instruction Papers. Among them may be mentioned—"Management of Dynamo-Electric Machinery" (in two parts), by Prof. F. B. Crocker, E. M. Ph. D., head of the Department of Electricity, Columbia University; "Electric Railways," by James R. Cravath, Western Editor of the *Street Railway Journal;* "The Electric Telegraph" (Part I), by Charles Thom, chief of the Quadruplex Department, Western Union Telegraph Company; "Strength of Materials" (Part II), by Prof. E. R. Maurer, B. C. E., University of Wisconsin; "American History," by Professor Scherger, Ph. D., Professor of History, Armour Institute of Technology; "Carpentry" (Part I), by Gilbert Townsend, S. B., Instructor in Architecture, American School of Correspondence.

There are several other excellent Instruction Papers in course of preparation, the most important of which are a series on "Alternating-Current Machinery" by Prof. William Esty, S. B., A. M., head of the Department of Electricity, Lehigh University. "Machine Design" (Part II), by Charles L. Griffin, S. B., now of the Semet-Solvay Company, Syracuse, N. Y., formerly Professor of Machine Design, Pennsylvania State College, will be published in a few days. The Architectural Course will soon have a new Instruction Paper on the "Study of the Orders," by Frank A. Bourne, M. S., a prominent Boston architect.

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A Silent Messenger

A letter sent January 15 in reply to an inquiry from a member of the staff of the Russo-Manchurian Commission Company, has been returned to the School from Yokohama, Japan, marked "Cannot be forwarded on account of war." The address of the correspondent is—or rather was—Harbin, China, the one-time chosen headquarters of the peripatetic Russian Vice-Admiral Alexieff. The letter is a mute reminder of how means of communication and normal conditions of business are upset by the present conflict in the Far East. It also shows the widespread influence of the American School of Correspondence, whose students now rally from every corner of the globe.

A Word from England

Mr. W. Brooks, of Staplehurst, England, a gentleman seventy years of age and still prominent in his profession, has written a very interesting and appreciative letter about the work of the American School. Referring to the opportunities for securing a technical education, Mr. Brooks gives this "leaf" out of his own experiences:

"What would I not have given in the days of fifty years ago for the opportunities such as your School offers! I will certainly see that these papers are put into channels where they may be useful. The means you place in the way of men should be grasped with earnest zeal and unfailing effort. Kindly go on urging the men of your great people to press onward and upward, and you will sow seeds which will bring you a rich harvest."

It would be an excellent thing if every young man in America could read and profit by the words of Mr. Brooks. Should this catch the eye of any man who has some thought of securing a technical education, do not be so foolish as to put the matter off; begin now, and the future will show the wisdom of your decision.

Think as Well as Work

At a dinner recently given by the National Association of Stationary Engineers, Col. E. D. Meier, one of the leading boiler manufacturers in the United States, said that Kipling's well-known poem, "McAndrew's Hymn," has a passage which describes the difference between the American engineer and the engineers of other countries. The poem reads:

"Ye thought?
Ye are not paid to think.
Go sweat that off again."

The American engineer is paid to think, and technical education is what makes him a thinker. It teaches him not only how to think, but how to carry out his ideas after he has thought them out. The engineer who thinks becomes more and more valuable to his employer. The Correspondence School is giving to thousands of men a technical education that makes them thinkers. By this education they are thoroughly equipped for higher things, and are soon found pushing their way to the front and winning the confidence of their employers.

WILEY UNIVERSITY, MARSHALL, TEXAS

An Interesting Account of the Work of an American School Student

The accompanying cut gives a view of the main building of Wiley University, Marshall, Texas, of which Dr. M. W. Dogan is president. When the building was erected, the plans called for mod-

DR. M. W. DOGAN.

WHEN YOU HAVE MADE *an* INVENTION

place it before a reputable patent lawyer, who will give you expert advice, usually without charge, relative to the best means of protecting it. Many valuable inventions have been lost to their inventors by following a different course.

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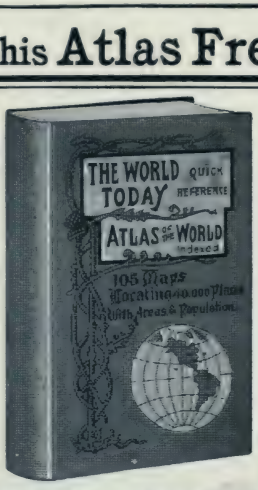

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An effort was made to induce the city Light & Power Company to extend its lines to the University. This proposition, however, did not meet with favor, and Prof. J. R. Reynolds, instructor in mathematics, urged that the University put in a private lighting plant. He undertook to look after the matter himself, and, in order to become familiar with the practical application of electricity, began a course in Electrical Engineering in the American School of Correspondence at Armour Institute of Technology. He fitted up a small room on the campus for a workshop, and although carrying his usual heavy class work at the time, conscientiously pursued the prescribed course. During his vacation, Professor Reynolds made a trip North, inspected several modern electric lighting plants, and also visited the American School at Armour Institute, where he consulted with the instructors and engineers as to the best machinery to use for the University's plant. Upon his return to Marshall, Professor Reynolds personally

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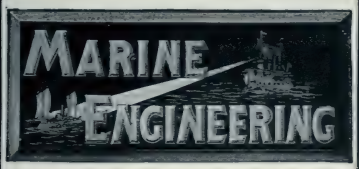

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which to run woodworking machinery, printing presses, and the like.

THE TECHNICAL WORLD congratulates Dr. Dogan on the splendid work accomplished by Wiley University; and the American School is indeed pleased to know that one of its students had so much to do with the present success of this important Texas school.

J. R. REYNOLDS, A. M.

ward, the first earth being turned December 19, 1892; and the dock was completed April 3, 1896. Since that time, many shops and other buildings have been erected. Appropriations have been made for still more, and plans for them are now being made. Mr. Holbrook sent THE TECHNICAL WORLD a very interesting souvenir of the navy yard. Two of the illustrations we reproduce.

Arthur Seguin, of Ottawa, Ontario, who is employed with the Empire Electric Manufacturing Company, tells, in his last letter to the School, that since his enrollment he has been promoted to the position of foreman. He rewinds drum armature field-coils and does all kinds of electric machine repairing.

William L. D. Gundry, of London, England, formerly of Christchurch, New Zealand, has recently accepted a position on the electrical staff of the Plymouth Corporation Electricity Works at Plymouth, England. He is engaged as shift engineer.

U. S. S. *IOWA* ENTERING DRY DOCK, PUGET SOUND NAVY YARD.

Personal Items

F. W. D. Holbrook, of Bremerton, Washington, has been employed in the Navy Yard at Puget Sound since 1892. The yard comprises about 200 acres of ground purchased by the United States Government in 1891. The contract for the dry dock was awarded shortly after-

H. Leonard Jones, of Bloemfontein, capital of the Orange River Colony, South Africa, in a recent letter, describes the flood which caused great loss of life and property in that city on January 17.

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GRADUATE AND STUDENT NOTES—(Continued)

VIEW OF BREMERTON, WASHINGTON, FROM CONNING TOWER OF U. S. S. *OREGON*, SHOWING PORTIONS OF PUGET SOUND NAVY YARD AND PORT ORCHARD BAY.

The Spruit river, which drains the vicinity surrounding Bloemfontein, rose so rapidly that within a few minutes it had overflowed its banks to a depth of ten feet and swept away everything in its

E. C. R. DEEFHOLTS.

path. Sixty lives were lost, and the damage to property in the business district was very extensive, not a trace of many of the buildings being left after the flood subsided.

Thomas Ashworth is now Chief Engineer of one of the largest pumping stations in Chicago, and has charge of four of the best Westinghouse engines in the city, at the Central Park Water Works.

Ernest F. Smith has been steadily advanced in the employ of the Chicago Edison Company and now holds a responsible position, being chief assistant to the operating engineer, Mr. Abbott.

Mr. E. C. R. Deefholts was enrolled in the American School while living in India. All his examination papers show the result of painstaking study. In his last letter to the School, Mr. Deefholts tells of his return to England. We take the liberty of publishing a notice from an Indian newspaper which refers to his departure for Great Britain and speaks of his prowess as a sprinter.

"Mr. Ernest C. R. Deefholts, the younger of the two amateur sprinters, who was unable to compete last season for the P. A. M. owing to illness, leaves by the French mail steamer today for London. We trust he will be able to compete next season for the English championship and gain as high a reputation on the English field as he has done on the Indian."

In a Civil Service examination for First Engineer's License in the Philippines, H. E. Burgess passed highest, competing with engineers from all parts of the United States.

In order to gain a practical knowledge, H. M. Patch, of Stevens Point, Wisconsin, has been assisting in the running of

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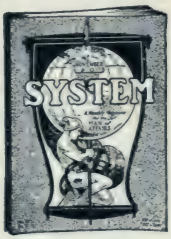

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GRADUATE AND STUDENT NOTES—(Concluded).

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George Topping, Milwaukee, Wisconsin, a graduate in two courses, holds the responsible position of engineer in the well-known Wells Building in Milwaukee.

William F. Buckalew, a graduate in the Electrical Engineering course, is chief engineer of the plant in the Philadelphia County Prison at Holmesburg, Pa. The equipment of the plant consists of five Edgemoor Iron Company's Galloway boilers of 150 H. P. each, three 100-H. P. and two 50-H. P. Westinghouse compound engines, three 60-K. W. compound-wound General Electric Incandescent dynamos, two eight-light Wood arc dynamos, all direct-connected. The heating and ventilating systems cover about five acres of ground.

WILLIAM F. BUCKALEW.

Silas M. Vanderford, of Florence, Tennessee, has been appointed by the Government as forage master, with headquarters at Fortress Monroe, Virginia.

LeRoy W. Clark, of Providence, R. I., has written a few practical letters, two of which appear in the January number of *Power* and *The Practical Engineer.*

T. E. Dutton, who is employed in the Dudbridge Iron Works at Stroud, England, has been promoted to a position of greater responsibility, and now tests and inspects the engines and assists the manager of the works.

C. L. Desmartin, of New Orleans, Louisiana, sent in to the School a very interesting report on the sugar industry in Cuba.

Notice to Subscribers

ARTICLES on technical, mechanical, and scientific subjects are solicited from subscribers, for publication in THE TECHNICAL WORLD. In every community incidents are frequently occurring which are of a technical character and of sufficient importance to have much more than a merely local interest—such, for example, as extensions of public works, installations of new machinery in large manufacturing plants, inventions of new mechanical devices, etc. It is the wish of the editors of this review, that our subscribers would, in a certain sense, constitute themselves into a staff of local reporters, on the watch for such items of interest, thus keeping the magazine in touch with the latest local advances along technical lines. Where illustration is desirable, manuscript should be accompanied with sketches or photographs; and the photographs should in every case be labeled with title and full details necessary for identification and adequate description. The necessary tracings and cuts will be made at our expense. All copy must reach us by the first of the month preceding publication. *See blank form on advertising page (viii) for suggestions as to desirable articles.*

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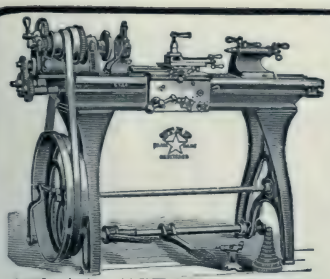

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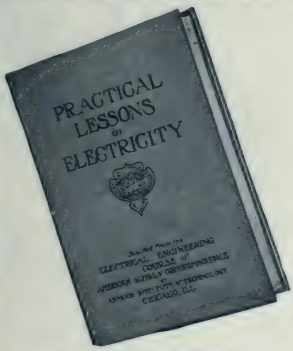

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BOOKS

Artificial Ice-Making and Refrigerating. By Louis M. Schmidt, Ph. B. Second edition. 8vo. Pages 300. Philadelphia Book Company. Publishers' price, $2.50 to any part of the world.

This is perhaps the best and most up-to-date textbook on Refrigeration. The various systems of refrigeration are outlined, and then followed by a detailed description of the machinery. The machines described are the Linde, De La Vergne, Featherstone, Boyle, Eclipse, York, Newburgh, Hall, Allen, and Vogt. The description of indicator cards is good. The chapter on Liquid Air is a valuable addition to a book of this kind, although the practical applications of liquid air to refrigeration are as yet undeveloped. On the whole we consider this the best book on refrigeration we have yet seen; it is certainly worth the small sum asked.

American Compound Locomotives. By Fred H. Colvin. Published by the Derry-Collard Company. Price, $1.00.

An excellent little book on the various types of compound engines. After a brief description of the theory and advantages of the compound engine, the author describes the two-cylinder compounds, such as the Baldwin, Pittsburg, Rhode Island, Richmond, Rogers, Schenectady, and Vauclaim. The tandem-compound is next taken up, and the peculiarities of the engines made by the various builders then pointed out. The explanation of the construction of the compound engine is followed by chapters on their management, including the operation of the reducing valves and the valve gear. An interesting chapter is that devoted to finding the power of compound engines. The book is beautifully illustrated, both with diagrams of sections of cylinders, and with half-tone cuts showing the entire engine.

Change Gear Devices. By Perrigo. Price, $1.00. Published by the Derry-Collard Company.

This little book is the result of a long investigation of the patents relating to change gears for engine lathes. Of the large number of patents issued, many naturally receive simply a mention, while others, the most important, are explained at length. The subject-matter describes patents from the time of Bancroft and Sellers in 1854, to that of Newton in 1903. While there is considerable literature on this subject, no book that has yet come under our notice explains in so re-

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liable a manner the various devices for arranging the gears for thread-cutting. In every case in this book, the number of the patent is given, and also its date, so that the references can be readily verified if desired.

American Steel Worker. By Edward R. Markham. Derry-Collard Company, Publishers. Price, $2.50.

A book by Mr. Markham must needs be practical. His long experience in this work makes him an authority. Beginning with the selection of the steel to be used for a given purpose, the reader learns how to heat, anneal, and harden various kinds of steel. Numerous illustrations show arrangement of furnaces, cooling tanks, and the proper way to handle tools to be hardened. The chapter "Steel for Various Tools" gives the composition of steel to be used for all kinds of tools. A striking feature of this book is its innumerable hints which are the results of experience in the actual handling of all brands of steel under all conditions.

Alternating Current Machinery. Part I. By Prof. Wm. Esty, S. B., A. M., Head of the Department of Electricity, Lehigh University. Pages 64. Published by the American School of Correspondence at Armour Institute of Technology.

This is the first one of a series of four Instruction Papers on Alternating-Current machinery. It takes up the theory, beginning with the fundamental principles, and logically develops the subject. The simple alternator is studied first, together with the subject of alternating electromotive forces and currents. Then follows a brief discussion of the advantages and disadvantages of alternating and direct currents. Next comes a comparison of the Power law, Ohm's law, Joule's law, and Kirchhoff's laws, for both direct and alternating currents. Throughout the book comparisons have been drawn, wherever possible, between direct and alternating current, as a person who is prepared to study alternating current must previously have mastered the principles of the direct current. Treated in this manner the difficulties of the subject are much lessened.

Another valuable feature of this work is its profuse illustration and the use of graphical methods, thus eliminating to a large extent the difficult and complex mathematics so often found in alternating-current texts.

Electric Railways. By James R. Cravath, Western Editor "Street Railway Journal." Pages 88. Published by the American School of Correspondence at Armour Institute of Technology.

Electric Railway practice has of late undergone what is almost a revolution, and in few other fields of electrical activity have developments been so rapid. This book, which is one of the Instruction Papers of the American School of Correspondence, is based upon the latest and best practice. It treats the subject almost entirely without mathematics and from a thoroughly practical standpoint. It discusses the trolley system, the third-rail system, and the conduit system. Under the head of car equipment may be found the subjects of car motors, controllers, and multiple-unit control, both the original Sprague system and the later General Electric controller system. Under the heading of "Accessories," the canopy switch, circuit-breaker, lightning arresters, etc., are taken up.

The air brake, as applied to modern interurban service, is explained; also the momentum brake, General Electric brake, and Westinghouse electro-magnetic brake. Overhead construction is fully covered, both for low-tension direct-current lines and high-tension alternating-current transmission.

The latest developments in the use of alternating currents are explained, both as applied to alternating current for transmission, being then changed to direct current by means of rotary converters, and also as applied to alternating current upon the cars together with three-phase or single-phase induction motors. The work ends with a section on "Operation and Testing."

Modern Practical Electricity. By R. Mullineax Walmsley. Three volumes. Pages 888. Published by W. T. Keener & Company. Price $3.00 per volume.

This work is in three volumes, being fully illustrated with 876 figures. The field which this work is planned to cover is a very broad one, being the applica-

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N. B.—The "Penberthy Bulletin" Three Months Free to any Engineer.

tions of electricity in modern life. This subject is treated more from the standpoint of the physicist than of the engineer, and is written in an interesting and popular style. The book in general represents English rather than American practice.

Volume I gives a brief historical review of electrical science, then taking up magnetism and static electricity, also the matter of batteries, lamps, and electro-magnetism, with a discussion of hysteresis.

Volume II takes up the general subject of magnetic effects of currents, and discusses measurements, alternators, and transmission of power, and the telephone. These subjects are treated from both a historical and a practical standpoint, and this volume seems to be particularly rich in historical types of machines.

Induction motors and rotary, converters are briefly treated in Volume III. Quite a good deal of space is given to interrupters, and wireless telegraphy is touched upon, also the subject of X-Ray photography. The latter part of Volume III is devoted to the subject of types of generators, showing methods of construction, armature windings, etc.

In general, this work is fitted for the popular reader who desires a general knowledge of the field, rather than for the engineer or the scientific expert.

CATALOGUES

L. C. Sharp, Omaha, Neb. Construction and Repair of Commutators. Pages 32. Paper, 3¼ by 6 inches.

This reference book—for machinists and others who have to do with dynamos and motors—is an interesting little pamphlet containing considerable valuable information in regard to the method of building commutators and keeping them in repair. The information contained in the book is of a practical nature, and the test of actual experience has been applied to it. The object of the book is to enable the reader to observe those points in commutator construction which must be considered in order to make this very important part of the dynamo or motor as durable as possible and to enable one to make repairs promptly and intelligently when necessary. The different processes mentioned are illustrated by cuts so that it is not difficult for any one to understand. An attractive and valuable pamphlet for those interested in the manufacture of commutators or in caring for dynamo-electric machinery.

Kellogg Switchboard & Supply Company, Chicago, Ill., U. S A. Magneto Telephone. Pages 88. Paper, 6½ by 9 inches.

As its name indicates this catalogue deals with the magneto telephone and its accessories, in the development of which the Kellogg Switchboard Company has been very active. This is a valuable addition to the library of any one interested in the telephone. It is profusely illustrated with very fine cuts. One of its most valuable features is the fact that it is thoroughly up-to-date. A brief sketch is given of the history of the Kellogg Switchboard & Supply Company and a brief survey of its facilities for turning out work. The essential parts of the magneto telephone—such as transmitter, receiver, induction coil, ringer, generator, etc.—are fully described and illustrated; and, as the instruments manufactured by this company represent the best modern practice, a careful study of the same will well repay the reader. The various types of telephones manufactured by the company are also described.

Wyman & Gordon, Worcester, Massachusetts.

This company, manufacturers of drop forgings, is issuing monthly biographies of engineers in place of catalogues. We are just in receipt of the April story, that of William Murdock, whose name is so intimately connected with Watt's inventions.

Among the biographies already published by this company are those of James Watt, Robert Fulton, George Stephenson, Sir Henry Bessemer, John Ericsson, Benjamin Franklin, John Stevens, Eli Whitney, Peter Cooper, Roger Arkwright, and Thomas Newcomen. These short biographies, with the exception of a few that are now out of print, will be sent free upon application.

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LITERATURE—(Continued)

L. S. Starrett Company, Athol, Mass. Pages 176. Paper.

Catalogue describing the large and varied line of fine mechanical tools manufactured by this well-known company. A particularly complete line of rules, squares, and micrometers is shown, and under the head of micrometers is given a discussion of the proper method of reading micrometer, and of using the vernier. All kinds of gauges, speed indicators, and calipers are also shown; and at the end are a set of tables with decimal equivalents, tapers, and angles, wire gauges, drills, etc.

Hazleton Boiler Company, New York City. Pages 150. Cloth. 6 by 9 inches.

Catalogue bearing title "The Generation of Power." The description of the Hazleton boiler is prefaced by a discussion on a boiler plant outlining the functions of the chimney, furnace, and boiler. Some of the subjects discussed in connection with boilers in general, and the Porcupine boiler in particular, are: Advantages of the Hazleton Boiler, Economical Combustion of Coal, Boiler Scale, Feed-Water Heaters, Flow of Steam in Pipes, Rating and Care of Boilers.

The Stirling Company, Chicago, Ill. Pages 100. Paper. 6 by 9 inches. "The Water-Tube Boiler in the Mercantile Marine."

This pamphlet is a reprint of a paper read before the annual meeting of the Society of Naval Architects and Marine Engineers, by William A. Fairburn. It is a valuable addition to the literature on this subject. Features to be considered in the design of water-tube boilers are stated clearly. In this pamphlet the following types are discussed and compared with the cylindrical fire-tube boiler: the Niclausse, Belleville, Babcock & Wilcox. Other features are short chapters on mechanical stokers for marine boilers, and on liquid fuel.

The American Track Supply Company, Chicago. "Track Economy." Pages 16. Paper. 6 by 9 inches.

This is Catalogue No. 1 describing the Bailey Surface and Lining Blocks for assisting trackmen in surfacing and lining tracks. It is claimed that with the introduction of this device a great saving is accomplished, as the foreman can do the work more quickly and efficiently. A description is given of the method of operation. If the track between two given points is too low, it is possible to tell at once, by means of this device, just how much too low it is, and also to tell when the low point has been brought up to the required height. The degree of a curve may be determined and adjusted to its alignment.

Niles-Bement-Pond Co., New York City. Paper. 9 by 12 inches.

Three catalogues—"Multiple Drills;" "Horizontal Boring Machines;" and "Horizontal Boring, Drilling, and Milling Machines." The titles of these catalogues indicate clearly the machines described. The half-tones are excellent, and are large enough to show the details clearly. The covers are excellent examples of lettering.

Luther J. Miller, Chicago, Ill.

Booklet entitled "Trade Marks." Topics discussed are: Offices of a Trade Mark, Influence of Trade Mark, Advantages of Registration, What Constitutes a Valid Trade Mark? etc. This neat booklet will be sent on request.

Henry R. Worthington, New York. Pages 48. Paper. 6 by 9 inches.

Catalogue describing Worthington's Centrifugal Pumps. In this catalogue are illustrated the three classes of centrifugal pumps—the conoidal, the volute, and the turbine.

Union Iron Works, San Francisco, Cal. Pages 164. Paper. 7 by 10 inches.

Catalogue No. 5, Metallurgical and Mining Machinery. Ore Crushers, Rock Breakers, Ore Feeders, Stamp Mills, Screens, Retorts, Roasting and Matting Furnaces, Engines, Boilers, etc.

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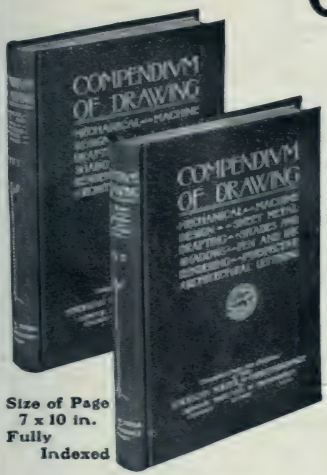

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PART II

Working Drawings and Mechanism by Prof. W. H. James, Mass. Institute of Tech. and Prof. C. L. Griffin.
Machine Design by Prof. C. L. Griffin, formerly Prof. of Machine Design Pa. State College, now with Semet-Solvay Co.
Sheet Metal Pattern Drafting and Tinsmithing by Wm. Neubecker, New York Trade School.

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AMERICAN SCHOOL OF CORRESPONDENCE, CHICAGO ILLINOIS

LITERATURE—(Continued)

The De La Vergne Refrigerating Machine Company, New York City. Pages 128. Cloth. 6 1-2 by 9 1-2 inches.

Catalogue of machinery for the Ammonia (compression) system. Like many trade catalogues, it contains much valuable data on this subject. The various applications are well treated and well illustrated.

Murray Iron Works, Burlington, Iowa. Pages 64. Paper. 7 by 10 inches.

Catalogue of Corliss engines, high-pressure boilers, and feed-water heaters. Excellent full-page cuts of Corliss engines. The various details are explained and illustrated.

Parks & Woolson Machine Company, Springfield, Vt. Pages 8. Paper. 6 by 9 inches.

Circular describing measuring, doubling, and rolling machine. The machine is illustrated by half-tones, and the specifications are given.

Jeffrey Manufacturing Co., Columbus, Ohio.

Circular No. 1, illustrating bits for coal-cutting machinery.

We have received the prospectus of a book soon to be published entitled, "The World's Greatest Invention, The Steam Engine." This book is being prepared by Chas. E. Manning, M. E., late Assistant Engineer, U. S. Navy. It is to contain a portrait and sketch of the life of each of forty of the world's benefactors including James Watt, George H. Corliss, and Thomas Edison.

MAGAZINES

Marine Engineering.

The leading article in the April number of *Marine Engineering* is a description of the new steamship *Mongolia* built for the Pacific Mail Steamship Company. The account of the test of a 15,000-gallon centrifugal pump, by P. P. Bird, is interesting on account of the difficulties attending the test of so large a pump. In this test the conditions were made as nearly as possible like those under which the pump was to work. The pumping was done into a tank and the fluid then discharged over a weir.

Other articles in this number are:

Uses of Superheated Steam by, Storm Bull.
English Shipbuilding Notes.
Lengthening the *Decatur H. Miller.*
Danish Steam Car-Ferry *Prins Christian.*
Old Steamer *Massachusetts* Broken Up.
New Boats in the Philippines.
Shipbuilding Bounties in Japan and Abroad.

The Engineer.

Two articles on gas engines are the most noteworthy in the number of *The Engineer* for April 1.

"The Gas Engine for Central Station Service," by Ralph Mershon, "begins at the beginning" by explaining the cycle of operation of the Otto type of gas engine. The subsequent discussion includes the methods of governing; a power gas generating plant; and the cost of engine and power.

The first article of a series on the inspection of plants appears in this number. If the following articles are as good as the one here presented, the series should contain many valuable ideas. This article is concerned principally with the testing of the armature and field. *The Engineer* announces that this series will also contain articles on the duties of a Chief Engineer.

Other articles in the number are:

Power Plant of the New England Confectionary Company, by H. R. Cobleigh.
Crank Pin Bearing, by C. H. Bierbaum.
The Russell Engine.

Power.

The second installment of the article on "Burning Powdered Coal," by H. J. Travis, appears in the April number of *Power.* Feeders and pulverizers are first discussed; then nozzles are shown attached to water-tube boilers, tubular boilers, and locomotive boilers. The article describing the setting of the valves on the Brown engine is valuable to those in charge of this type of engine. In this number is found a second article on

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LITERATURE—(Concluded).

"Lubricating Oils and Their Properties," by Wm. Davis. The determination of flash-point and the fire test, which we looked for in the March number, are well explained for the engine runner.

Other articles of interest are:

Briquetting Fuel Material, by George E. Walsh.

Antiquity of the Rotary Engine, by E. P. Buffet.

Reeves Vertical Cross-Compound Engine.

Reciprocating Sets vs. Turbo-Generators.

The Selection and Testing of Lubricants, by A. O. Doane.

The Economy of Reciprocating Engines at Light Loads as Compared with that of Steam Turbines, by J. A. Seymour.

Cassier's Magazine.

The April number of *Cassier's Magazine* contains several articles of interest to engineers. The Location of Electric Water-Power Stations, by Alton P. Adams, is perhaps the most interesting. In this article Mr. Adams describes, with fine half-tone illustrations, types of power stations in which the power houses are located at the dam or at a little distance therefrom. Most of the power houses mentioned have horizontal shafts for the turbines, as this is most successful in operation, especially for low heads. The most important power station having a vertical shaft is that at Niagara.

Another article worthy of note is that on the Softening and Purifying of Water for Boilers, by J. C. W. Greth. While this article is naturally of special interest to steam engineers, it can be read with profit by others. The various impurities in water and the devices for their removal are carefully explained. The composition of various boiler compounds, with the cost of the constituents, is given. The two systems of water softening, the "continuous" and the "intermittent," are taken up in the last part of the article.

Other articles in this magazine are:

The Highest Railway of Europe, by Enrico Bignami.

The Modern Development of Docks, by Brysson Cunningham.

The Industrial Advance of Germany, by Joseph Horner.

Electric Power in British Shipyards, by C. S. Vesey Brown.

Equitable Labor Compensation and Maximum Output, by H. L. Gantt.

Edison and the Incandescent Lamp.

New American Woodworking Industries, by George E. Walsh.

Electrical World and Engineer.

One of the most interesting articles in the issue of April 9 is entitled "Booster Calculations," by Wm. A. Del Mar. This discusses the subject of the booster method of regulating voltage as applied to electric railway work. In railway work the fluctuations in load are very great; and consequently the fall of voltage is at times sufficient to cause the lights at distant points on a line to burn dim, and the car motors to fail to develop their normal speed. The function of the booster is that of making up for this drop of potential, and it is therefore admirably adapted for railway service. By this means a small amount of cable may be used and the drop of potential will be as small as if the cables were greatly increased in size. This allows a very great saving in investment in copper. This article is illustrated with diagrams which show the action of the booster very clearly, both for the positive and the negative booster.

F. G. Baum, in his article on "Synchronous Converters," says that the great importance of the synchronous converter at the present time can hardly be overestimated, one of its principal applications being to railway work where alternating current is transformed to direct current for use in the cars. In this article the theory of the rotary converter is developed for the single-phase, two-phase, three-phase, and six-phase systems, the six-phase having some advantages over the others. The article ends with a discussion of armature reaction and the compounding of converters.

There are also articles on:

Steam Turbine and Other Features of the Port Huron Light & Power Company's Station.

Telephone Substation, by Abbott; etc.

Employment Department

¶ TO EMPLOYERS—The editors of THE TECHNICAL WORLD will be glad to bring employers of skilled labor into communication with trained and efficient men. Write the Employment Department full particulars as to the qualifications necessary. ¶ STUDENTS AND GRADUATES of the American School are entitled to one insertion under the heading "Positions Wanted," free of charge. Subsequent insertions must be specially ordered, and will be charged for at a nominal rate.

POSITIONS VACANT

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POSITIONS WANTED

WANTED—A young man of 20, good habits, graduate of American School of Correspondence, and recently a student at a technical school, desires a position at electrical work, with chance to get practical experience. Can furnish references. Address *The Technical World*, No. 154.

WANTED—Position as apprentice in electrical or mechanical work. Would prefer electrical, where a practical knowledge of electrical machinery can be gained. Address *The Technical World*, No. 155.

A graduate of the American School, with long experience in the installing and practical running of woodworking and metal-working machinery, desires position as superintendent. Forty-five years of age and married. Can give best of references. Salary $125 a month. Address *The Technical World*, No. 132.

WANTED—Position as Stationary Engineer by young man having had six years' experience in the work. Desire employment in the Eastern States. Least salary accepted, $18.00 per week. Address *The Technical World*, No. 174.

SITUATION WANTED—Have had 20 years' experience as millwright and in carpentry; also familiar with mining, mining machinery, and drawing. Prefer to locate with machinery manufactory. Best of references. Address *The Technical World*, No. 170.

Student in Electrical Engineering course, completed same through geometry, wants a position as electrician in or near St. Louis, Mo. Age 22. Does not mention any previous experience. Address *The Technical World*, No. 172.

WANTED—A student of the American School of Correspondence, 35 years old and of steady habits, desires position under some good engineer. Would work for moderate wages to start. Wish a place to obtain practical knowledge of firing and engine running in stationary plant. Address *The Technical World*, No. 171.

WANTED—Position as Accountant and General Office Manager of Iron Industry, Mining, Machine Shop, or Foundry. Best of references. Salary $1,200. Address *The Technical World*, No. 184.

EMPLOYMENT DEPARTMENT—(Continued)

POSITION WANTED—Young man of 19, having had some experience, wishes position as assistant in installing electrical machinery. Lowest salary accepted $40 per month. Location immaterial. Address *The Technical World,* No. 156.

WANTED—Position as stationary engineer in the eastern part of Kansas by a young man of 29, having had about two years' practical experience. Salary to begin $2 per day. Address *The Technical World,* No. 158.

A young man with some experience in lighting and engine-room work desires a position as helper in lighting plant. Will start at $40 per month if chance for advancement. Am now located in S. W. Address *The Technical World,* No. 159.

WANTED—Position as surveyor's assistant in the state of New York by young man who desires to acquire practical experience in the use of instruments, etc. Student of American School of Correspondence. Address *The Technical World,* No. 160.

A single man of 28 having twelve years' experience in machine repairing and operating engines wishes a position as Stationary Engineer or Machinist. Salary $65 per month. Location preferred, Kansas or Nebraska. Address *The Technical World,* No. 161.

WANTED—Position as draftsman with firm making hoisting or mining machinery, by Swede of 27 with technical education and 7 years' shop and drafting-room experience, especially steam engines and hoisting machinery for mines. Capable as designer and can take charge of work in drafting office. Chicago preferred. Address *The Technical World,* No. 162.

Young man of 23, having had some experience, wishes position as dynamo tender in Central Station. Prefers employment in a town of about 1,000. Lowest salary accepted $12 per week. Address *The Technical World,* No. 163.

A young man with four years' experience desires a position as steam or electrical engineer. A. S. C. graduate. Well recommended. Address *The Technical World,* No. 164.

WANTED—A position as stationary engineer. Have had 20 years' experience with steam plants and machinery. Age 43 years. Strictly sober and industrious. Want steady place. References if required. Address *The Technical World,* No. 165.

POSITION WANTED—By experienced man as draftsman or designer; small shop preferred. Has almost completed course in American School of Correspondence. Would prefer a position in Massachusetts. Will want $1,200 per year. Address *The Technical World,* No. 166.

A young man with no experience desires a position as assistant draftsman. Nearly completed the American School of Correspondence course in Mechanical Drawing. Address *The Technical World,* No. 167.

A graduate of the American School of Correspondence with seven years' experience wishes a position as machinist. Prefers the state of Connecticut, although a position in any of the New England states would be considered. Address *The Technical World,* No. 168.

WANTED—Position as foreman or superintendent by a young man experienced in general construction and operation of light and power systems. Best of references. Address *The Technical World,* No. 169.

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WANTED—Position as Superintendent, Erecting Engineer, or Draftsman, by young man with wide experience in different kinds of mills. Salary $100 per month. Locality immaterial. Address *The Technical World,* No. 130.

Stationary Engineer, or assistant. By American 30 years' old, married, 6 years' experience in traction engines. Position wanted at salary of $60 a month. Address *The Technical World,* No. 147.

Mechanical Draftsman. A classical college graduate, 22 years old, single, experience in clerical work and figuring cost on work in factory, desires position. Salary, $12 a week. Address *The Technical World,* No. 151.

Chief Engineer. A machinist of 14 years' experience, American, 28 years of age, married, desires position. Salary $100 a month. References. Address *The Technical World,* No. 149.

Position wanted in an Electrical Machine Shop by Grammar School graduate 19 years of age; three-fourths year's experience in telephone electrical work. Of Bohemian nationality. Single. Salary $10 a week. Address *The Technical World,* No. 142.

Stationary Engineer. Frenchman 37 years old, married, with 14 years' experience desires position. Can give best references. Lowest salary accepted, $75 a month. Address *The Technical World,* No. 150.

An American 20 years of age, single, experienced in car repairing and inspecting, desires position as electrician. Salary, $12 a week. Address *The Technical World,* No. 146.

As Superintendent in machine or wood shop. Position wanted by American 47 years of age. Has had 30 years' experience and can show best of references. Salary, $125 a month. Address *The Technical World,* No. 132.

Position wanted as Assistant Electrician by American 21 years old, single, experienced as operator in telephone exchange and in line work. Salary $30 a month. Address *The Technical World,* No. 138.

Clerical or office work. A German-American, 30 years of age, married, desires position as clerk or in office work. Has public school and business college education. Experienced in carpentry. Salary $12 a week. Address *The Technical World,* No. 144.

To run electric light plant. Position wanted by American 27 years of age, single, with 7 years' experience. Has run small plant 7½-25-K. W. in marine service. References. Address *The Technical World,* No. 143.

Electrician or Superintendent. Position wanted by American 31 years of age, married, with 10 years' experience in construction, wiring, and general station work, direct and alternating plants. Salary, $60 a month. Address *The Technical World,* No. 145.

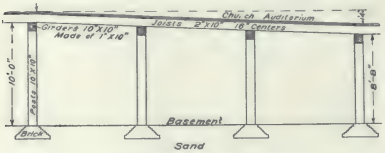
WANTED—Position as Electrical Engineer (apprentice) by American 21 years of age, single, experienced in setting up and operating all kinds of farm tools. Salary $30 a month. Address *The Technical World,* No. 137.

A young man, 22 years of age, with High School education, desires a position as engineer's helper. Address *The Technical World,* No. 179.

In order to receive attention in the columns of THE TECHNICAL WORLD, all inquiries must be addressed to the Consulting Department

Required Size of Iron Columns

Question: I am already taking advantage of some of the good things your school offers. Would you please give me a little advice in the following? It is wished to economize the space in the basement as much as possible. Now, what sized iron columns would exactly take the place of the posts? I enclose a sketch to show arrangement.—*G. Van R.*



Answer: Your inquiry, together with your sketch has been received. You cannot economize the space to any great extent by substituting iron posts for those you have; moreover, they would cost much more than the wooden ones. The amount of space saved would not make up for the extra cost. The post which you have shown is 10 inches square; and since you do not specify the material, it may be assumed to be of hard pine. The longest post has a length of 10 feet from the top of the foundation to the top of the girder. Although the actual post is a little shorter than this, it will be safe to assume 10 feet as the total length. The ordinary pine post will carry something less than 1,000 pounds per square inch of section, the amount of reduction depending upon the length of the post. This reduction is expressed by the formula,

$$P = 1{,}000 - \frac{10\,L}{D},$$

in which P is the safe average load per square inch, L the length of the post in inches, and D its least width in inches.

Applying this formula, you would have 1,000—120 (or 880) pounds per square inch for the safe load on this post. Since the section of the post is 100 square inches, the total load would be 88,000 pounds. To support this load, would require a hollow round cast-iron column 6 inches in diameter, with a shell of ¾-inch metal. Such a post has an area of 12.4 square inches, and, if 10 feet long, will carry a load of 82,000 pounds. This is not quite equal to the load on the wooden post; and if desired, a cast-iron column of ⅞-inch metal might be used, which will carry a load of 94,000 pounds and has an area of 14.1 square inches. A cast-iron column will carry a little less than 10,000 pounds per square inch, the reduction depending upon its length; and this safe load is expressed by the following formula:

$$P = \frac{10{,}000}{1 + \frac{l^2}{800\,d^2}}$$

In this formula P=load in pounds per square inch, l the length in inches, and d the diameter in inches.

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CONSULTING DEPARTMENT—(Continued)

Does Gravity Act on Steam Traps?

Question: I understand the action of a return steam trap like the Bundy to be due to gravity; that is, when the bowl fills with water it overbalances the ball weight, and in dropping admits steam, which forces the water out. When the bowl is empty, it returns to its original position, and the operation is repeated. Now, I want to know why the bowl does not return after a very small amount of water—say a fraction of a pound—is forced out by the steam. In the sketch, Fig. 1, which I enclose, the weight W is 25 pounds and the effective lever arm is 12 inches. This gives 12×25 (or 300) for this side of the balance. The bowl B, filled with water, weighs 100 pounds, and the effective lever arm is 6 inches. Since half the weight is supported by the trunnion T, this side of the balance gives (½×100) ×6 (or 300). Just as soon as one pound of water or even less is added, the bowl overbalances the ball weight; and when this small additional amount of water has been forced out, I should think the bowl would return. In other words, if gravity acts, why does the bowl remain down until it is empty?—*A. S. L.*

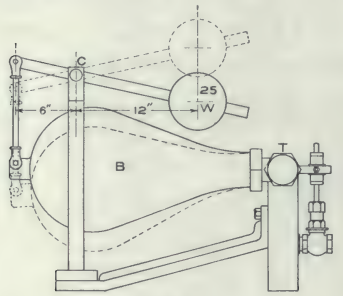

Fig. 1.

Answer: You are correct about the action of this form of trap being fundamentally based upon gravity, and it is also true that the trap would not be at all successful if the action repeated itself by the addition of a pound of water or less. As a matter of fact, the bowl does not return after being once overbalanced, until practically all the water has been forced out. This action is brought about by a slight change in the arrangement, which you have not shown in your sketch; and indeed this modification is essential. The accompanying sketch, Fig. 2, shows the change referred to. You will see that the rocking lever, is provided with a *point,* so that, when the tilting takes place, the 25-pound weight is shifted on to a shorter lever arm, while a slightly longer lever arm is provided for the bowl. The full lines represent the original position of the lever, and the dotted lines the position after the bowl has dropped. You see from the latter that the effective arms are 10¼ and 6¾ inches respectively.

The ball side of the balance then gives 25×10¼ (=256¼). Since the weight

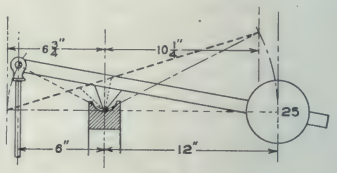

Fig. 2.

on the other side of the balance is still 300 pounds, considerable water can be removed from the trap before the ball will overbalance the bowl. Assuming that the bowl holds 25 pounds of water, the weight would be 75 pounds after this has been removed; and allowing one-half of this weight to be supported by the trunnion, as before, we have 37½×6¾ (=253) for the other side of the balance. This is less than the balance on the ball side of the lever, and consequently the bowl rises and the operation repeats itself.

The important point is that the trap is provided with a bent lever instead of the ordinary straight lever turning about a pivot, such as you have shown in your sketch.

Flanges on Field Frames

Question: In large-sized generators, the field frames or yokes are sometimes stiffened by flanges. Why is it necessary to do this? —*W. D. M.*

Answer: This should be done in order to allow the frame or yoke to resist the severe magnetic strains put upon it when the machine is running under load. There is an interaction between the field due to the field magnets and that due to the current in the armature, which tends to prevent the armature from revolving. This accounts for the comparatively large amount of power required to turn the armature when the machine is loaded,

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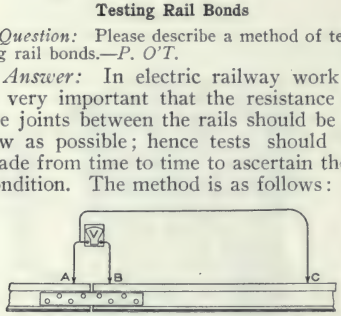
CONSULTING DEPARTMENT—(Continued)

while it may be turned easily when not loaded. Now, if the armature be made to rotate by means of an engine, in spite of this tendency to remain at rest, there is a tendency for the pole-pieces to be carried around with the armature. Since these are fastened to and supported by the frame, the latter must be very rigid in order not to be sprung out of shape.

Testing Rail Bonds

Question: Please describe a method of testing rail bonds.—*P. O'T.*

Answer: In electric railway work it is very important that the resistance of the joints between the rails should be as low as possible; hence tests should be made from time to time to ascertain their condition. The method is as follows:



The resistance is so low that it is difficult to measure it directly; hence it is usually found in terms of length of the rail. In the accompanying sketch, V is a milli-voltmeter reading on both sides of zero. The points A and B are connected on opposite sides of the rail joint; the voltmeter will accordingly show the voltage drop across the joint, and will give a reading. Now move contact C until the voltmeter gives a zero reading, and we have the drop in A B equal to the drop in B C, or the resistance of A B equals that of B C. In other words, we now have the resistance of A B in terms of a known length of rail. Then, by means of a table showing the resistance of different weights of rail, it is possible to obtain the resistance of the joint in ohms.

If a voltmeter with zero reading in the center is not available, an ordinary voltmeter may be substituted, and the adjustment as to balance made so that there will be no deflection.

Resurveying Old Surveys

Question: Why is it that in resurveying old surveys, though one may have the present variation of the needle from the true line, the old line cannot be run by that variation, but must be run with the variation at the time it was originally laid out? For instance, a piece of ground is laid out, and lines and corners marked, the variation of the needle being taken out of all courses run, so that they are true lines. Then, say twenty years after, the same piece of ground is resurveyed, and, after taking out the present variation of the magnetic meridian, the lines are re-run at the proper angles with the true meridian, and they will not agree with the former lines by some considerable distance. Is this because the first surveys were incorrect, or does the true meridian vary from year to year?—*E. J. R.*

Answer: The true meridian, of course, never varies. The relative variations of the needle at different seasons of the year are considerable, and the instrument should be tested and the variation derived as often as possible. The trouble that you refer to in resurveying old surveys is probably due to the fact that the original survey took no account of the declination at the time the survey was made; or, if it did, then in the resurvey you have failed to make corrections for the original variation. In either case the lines would fail to coincide.

Before the introduction of the United States Government system of land surveys, the work of laying out land was carried on without regard to magnetic declination, and this has been a source of endless litigation.

Fire Test and Flashing Point of Oil

Question: What are meant by "fire test" and "flashing point" of oil?—*F. W.*

Answer: Any oil can be heated to such a temperature that the evaporation will be sufficient to feed a flame from its surface without the aid of a wick. The determination of this temperature is called its "fire test."

The "flashing-point," which is a little below the "fire test," is the temperature at which a vapor is formed sufficient to support a flame for an instant, but not permanently. No oils, as such, will burn; much less do they explode. The vapors of oils burn, and, when properly mixed with air or oxygen, explode. Oxygen is necessary to combustion, and for the most part it is found in the atmosphere. A continuous flame in burning oil requires a constant supply of air and vapor

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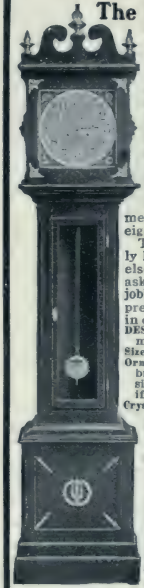

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at the point of combustion. The wick of a candle or lamp simply serves to aid in vaporizing the oil. A quart of water can be evaporated quite rapidly by sprinkling it upon suspended cotton goods, but it would require a long time if left in the cup. For this reason "standard" oil, which will not burn in a vessel at ordinary temperatures without a wick, will easily take fire when thrown upon porous substances, like clothing, carpets, etc. Heat stimulates evaporation. The heat generated by the combustion of a burning wick keeps up evaporation, which nearly ceases when the flame is extinguished.

When a quantity of combustible vapor or gas becomes thoroughly mixed with air in proper proportions, and the compound is confined, ignition produces an explosion. This is also true of ordinary illuminating gas made from coal. Accidents from coal gas are not likely to occur because the superior density of the air forces the separation, and, in most cases, the escape of the gas. On the other hand the vapors of naphtha and gasoline, being heavier than air, force the air out, if there is a chance for it to escape, leaving the vessel filled with the vapor, pure and unmixed.

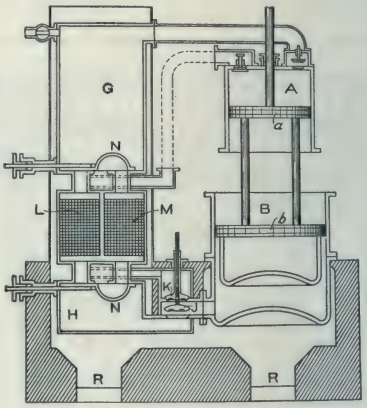
We can readily see why there is much less danger of accident, when the tanks, barrels, lamps, etc., containing petroleum, are filled with the liquid, than when only partially filled. Flame will not ordinarily enter a can containing naphtha, but the substance will burn quickly at the nozzle; flame is more likely to enter a can containing a little oil of heavier gravity, and will possibly explode it. A burning, heated lamp partially filled with oil is liable to explode by sudden cooling, as air rushes in to fill the vacuum made by the condensation of the vapor, carrying the flame of the wick with it.

Hot-Air Engine

Question: Kindly explain the working of the Ericsson hot-air engine.—*H. W. B.*

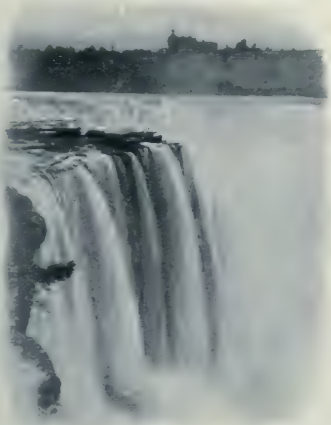
Answer: The working principle of hot-air engines is nearly the same as that of the steam engine. In the steam engine, water is pumped into the boiler, where it is converted into steam by the addition of heat. This steam does work by expanding behind the piston in the steam cylinder. In hot-air engines, the same thing takes place, except that the working substance is a gas at all times.

The accompanying diagram shows the construction of the Ericsson engine.



There are two cylinders—B, the working cylinder; and A, the supply cylinder, which forces the supply of air into the reservoir G. L and M are re-generators, which consist of cylindrical vessels filled with wire gauze or any other material that absorbs heat readily. H is the heater, R the furnace, and J and K the admission and exhaust valves to the working cylinder. The air from the reservoir is admitted into the heater through one re-generator while the hot exhaust air from the cylinder is passing through the other into the atmosphere, the object being to give the fresh charge of air most of the heat, which is in the exhaust. This alternate passing of the exhaust and fresh charge through the re-generators, is produced by the slide valves NN.

From the illustration, the operation is quite evident. The pressure is the same throughout, but useful work is done by the surplus area of the piston, *b*, over that of *a*.



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CONSULTING DEPARTMENT—(Continued)

Setting Valves of Duplex Pump

Question: Please give me an explanation of the method of setting the steam valves of Worthington and Smith-Vale duplex pumps.—*M. S. C.*

Answer: To set the valves in a Worthington duplex pump, first move the piston to one end of the stroke, until it strikes the cylinder head. Scratch a mark on the piston rod at the stuffing box. Repeat this operation for the other end of stroke. These marks can now be used to determine the stroke of the pump and to place the piston in its central position. Remove the valve-chest covers and measure the width of the steam ports, and the travel of the valve stem when the steam piston moves from one extreme end of the stroke to the other. Now place the pistons of both sides and the steam valves in central position, and make the distance between the tappet head and tappet jam nuts equal to one-half the valve stem travel minus the width of the steam port. The valves are now set, and it will be necessary only to replace the valve-chest cover and move one of the pistons to the end of the stroke, when the pump will be ready for service.

The above method applies as well to the adjustment and setting of the Smith-Vale valves. If in either pump the piston does not travel full stroke on the one side, adjust the valve by making the distance between the tappet head and the jam nuts greater; and decrease this distance if the piston strikes the cylinder head. A very small adjustment here will make quite an appreciable change in the stroke of the piston.

Boiler Pressure for Locomotives

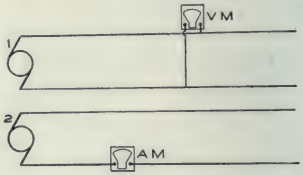
Question: What working pressure is generally carried on railroad locomotives? Do any locomotives use pressures as high as 250 pounds?—*A. V. and C. N.*

Answer: Locomotive boilers are usually designed to stand a pressure of 160 to 190 pounds (guage), the average being 180 pounds. A few of the late Baldwin high-speed locomotives are worked under pressures as great as 200 pounds; but so far as we are aware, no locomotive boiler is in use in which a pressure as high as 250 pounds is carried.

Resistance of Voltmeter and Ammeter

Question: Why should a voltmeter have a high resistance, and an ammeter a low resistance?—*A. C. L.*

Answer: In Fig. 1 is shown a voltmeter which is connected across the mains in parallel, and in Fig. 2 is shown an ammeter connected in series with the mains. Now, the loss due to a current flowing



through a resistance is equal to the square of the current multiplied by the resistance, or I^2R. Since the voltmeter is connected in parallel, this resistance should be very high (in the neighborhood of 15,000 ohms), so that it may take only a small amount of current from the line. On the other hand, the ammeter, being connected in series, must have a low resistance so that the I^2R loss may be as small as possible. In the case of the voltmeter it is possible to reduce the current by increasing the resistance, and hence it is desirable to do this. In the other case the current is fixed and cannot be reduced; hence we keep down the I^2R loss by reducing the resistance.

Increase of Gasoline Expansive Power

Question: Would picric acid or potassium bromide in gasoline increase its expansive power?—*P. A. St. J.*

Answer: Picric acid has a formula $C_6H_3N_3O_7$. It is slightly soluble in water; it is a strong acid, and, when heated, rapidly decomposes with explosive violence. It forms many salts that explode with terrific force upon heating or when struck. The chief use of picric acid is in the manufacture of explosives;

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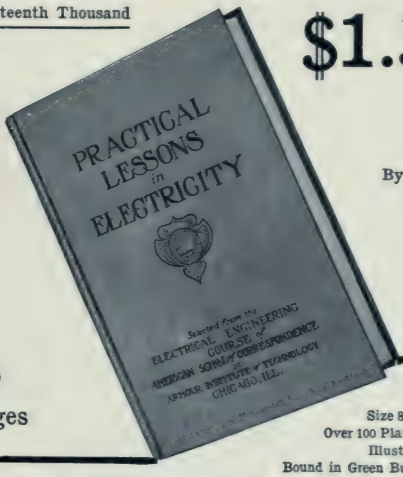

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it is also used to a small amount for dyeing purposes.

We do not know that any work has been done upon increasing the power of gasoline by means of picric acid; at least, we have been unable to find any references to that effect. We should consider it too dangerous an explosive to dissolve in gasoline. Potassium bromide would not increase the expansive force of gasoline; but, like common salt, it would increase the luminosity of the gasoline flame for lighting purposes.

Solder for Aluminum

Question: What is a good solder for aluminum?—*W. McD.*

Answer: The solder consists of aluminum 5 parts, antimony 5 parts, and zinc 90 parts. To make it harder, use a little more antimony and a little less zinc. The following is the process of making the solder, and the method of using it:

The aluminum is first melted in a pot. The zinc is then added; and when this is melted, the antimony is added. The metal is then thoroughly puddled with sal ammoniac. When the surface of the metal is quite clear and white, it should be poured into sticks ready for use, the cinders being first removed.

To make joints in aluminum with this solder, the two or more surfaces to be joined should be cleaned, either by scraping or by using acid; and the surfaces should be well coated with the solder, special care being taken that the solder penetrates into the surface of the metal without burning it. The parts to be joined should then be placed together and kept in close contact. Heat should now be applied till the solder melts, any surplus that squeezes out being wiped off.

Engine with Double Eccentrics

Question: In your last number you have shown a 9×12×24 cross-compound Corliss engine with double eccentrics, built by the Allis-Chalmers Company. Please explain the cross-compound-condensing engine, and what the two eccentrics are for.—*W. J. M.*

Answer: In simple engines, steam is admitted to the cylinder and performs its work during one stroke, and is allowed to exhaust into the atmosphere on the return stroke. In compound-condensing engines, the steam is first admitted into the high-pressure cylinder and does its work. On the return stroke, instead of exhausting into the atmosphere, the steam exhausts into a receiver which is directly connected to the low-pressure cylinder. Since the low-pressure cylinder has a greater volume than that of the high-pressure, the steam will expand and perform useful work in the low-pressure cylinder. On the return stroke of the low-pressure cylinder, the steam exhausts into a condenser in which the pressure is about 12 pounds below that of the atmosphere. An engine is cross-compound when the cylinders are placed side by side, the steam of the high-pressure head-end being crossed over to the crank end of the low pressure.

The object of using a double eccentric on the Corliss engine is to accommodate large variations of load. When a Corliss engine has one eccentric, the cut-off can be varied from zero to about ⅜ of the stroke; but when double eccentrics are used, one to operate the steam and the other the exhaust valves, the cut-off can be varied from zero to about ⅞ of the stroke. Thus, if the load is variable, it is advisable to use double eccentrics.

The reason why a single-eccentric Corliss engine cannot be made to cut off later than about ⅜ of the stroke is explained as follows:

In a single-eccentric engine, the steam and exhaust valves must be operated by one wrist-plate. When the crank is on head-end dead center, the head-end exhaust valve must be closed, while the head-end steam valve is open. As the piston moves through the stroke, the steam valve can be open only through one-half the stroke at the very most, because, while the steam valve is being opened, the exhaust valve is being closed. The exhaust valve must open at the end of the stroke; and therefore, if it is being closed during one-half of the stroke, it will take another one-half to open it for release. Therefore, since the steam valves and exhaust valves are operated by the same wrist-plate, it is theoretically possible to have the steam valve opened

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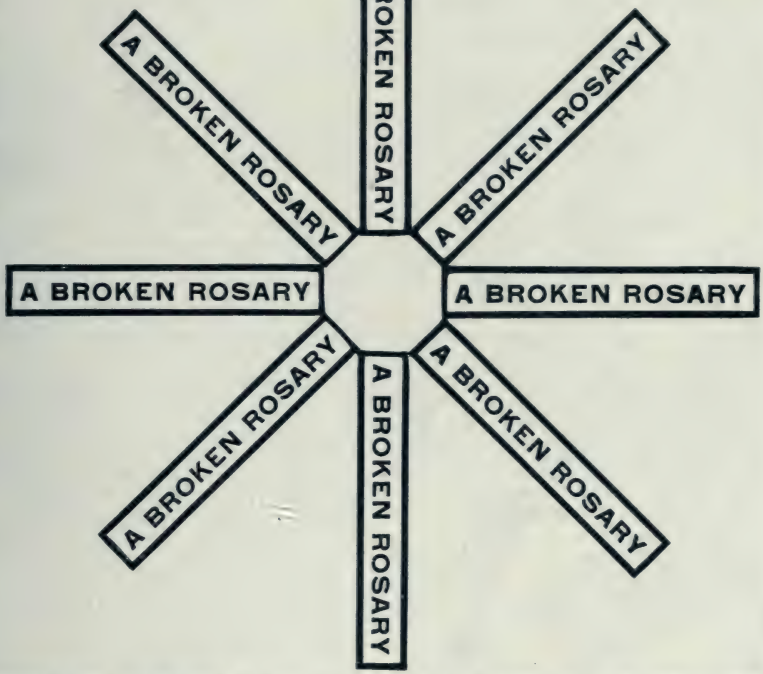

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only during the first half of the stroke.

In Corliss engines, the cut-off is produced by a trip mechanism; and if the trip mechanism does not work during the time in which the steam valve is being opened, it will fail to work. Therefore, the latest possible cut-off in an engine with a single eccentric is one-half the stroke; but in actual practice there is always a certain allowance made for lead, and the limit is therefore about ⅜ of the stroke. In double-eccentric engines, the exhaust and steam valves are independent of each other, and therefore the cut-off can be carried as far as ⅞ of the stroke.

Impedance of Choke Coil

Question: Why does a choke-coil offer a high resistance to a lightning discharge and still not impede the passage of a high-potential current?

Answer: The explanation lies in the nature of a lightning discharge. It is oscillating in character, and the frequency is extremely high, being far above anything ever encountered in commercial work. This accounts for the great impedance of the choke coil to its passage. The choke coil offers no impedance to a direct current after it is once established, no matter how high its potential. For alternating-current work, choke coils are made of a few turns of wire of large radius; hence the reactive effect on the alternating current is slight at the low frequencies used; but still there is sufficient impedance to the high frequency of the lightning discharge to cause it to pass across the air-gap to the ground rather than through the choke coil.

Boiler Horse-Power

Question: I have learned that a boiler horse-power is equal to 33,317 B. T. U. per hour, and also that one B. T. U. is equal to 778 foot-pounds. Also I have seen it stated that 33,000 foot-pounds of work in one minute is one horse-power. I am at a loss to understand clearly the relation of these figures to each other, and the apparent discrepancy. In other words, how is it that one H. P. is equivalent to only 33,000×60 foot-pounds per hour, but is still equal to 33,317 B. T. U. per hour, and a B. T. U. is equivalent to 778 foot-pounds?—*H.*

Answer: You are confusing two distinct units. One is a "boiler H. P.," and the other the unit of work which measures the power of steam engines and other prime movers. While the latter unit has been recognized since the time of Watt's first steam engine, as the production of 33,000 foot-pounds per minute, the former is an arbitrary unit which has only recently been standardized. It is equivalent to the evaporation of 34½ pounds of water from and at 212° F. per hour. This gives 34½×965.7 (heat of evaporization at 212° F.; =33,317) B. T. U. per hour, for the boiler H. P.

The thermal equivalent of 33,000 foot-pounds, is 33,000 ÷778 (=42.42) B.T.U. per minute, or 60×42.42 (=2,545.20) B. T. U. per hour. The unit of boiler H. P. is thus seen to be 33,317+2,545 (about thirteen times greater), and we may say that this difference was brought about by the low efficiency of the average steam engine of to-day. For example:

$$\frac{2{,}545\ \text{(thermal units per hour)}}{965.7\ \text{(heat of evaporization)}} = 2.6\ \text{pounds},$$

the quantity of water theoretically required to develop one indicated H. P. per hour.

In practice it has been found that the average simple engine can produce only one H. P. per hour on being supplied with 30 lbs. of steam, its equivalent being 34½ pounds from and at 212° F. This quantity is 34½÷2.6 (or practically 13) times greater than the theoretical amount.

We see, then, that the boiler H. P. represents about 13 times the *theoretical* energy necessary to produce one indicated H. P., or it represents the *actual* energy necessary to produce one H. P. in the average engine.

Let us suppose a 100-H. P. boiler supplies steam to a compound-condensing engine using but 16 pounds of steam per H. P. per hour. The H. P. of the engine is (100×30) ÷16 (=188, nearly). Let us now suppose that the same boiler is supplying the same quantity of steam, but is connected to a simple slide-valve engine using 35 pounds of steam per H. P. per hour. The H. P. of this engine is (30×100) ÷ 35 (=86, nearly). Thus we see that the same boiler, steaming under the same conditions, can supply a 188-H. P. engine or an 86-H. P. engine.

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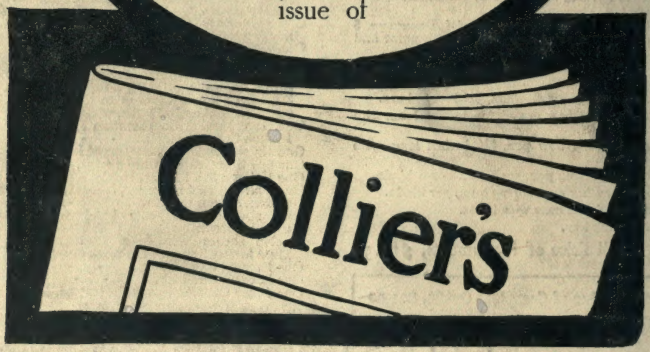
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